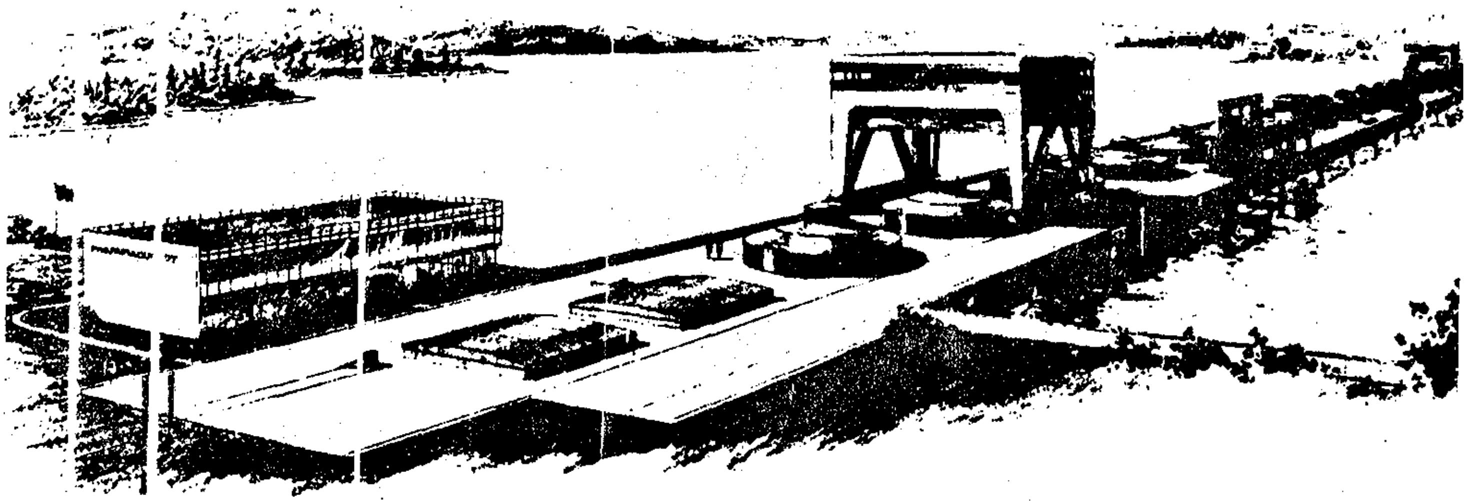
INVESTIGATION OF THE INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT



PRELIMINARY
ECONOMIC FEASIBILITY STUDY
FOR
INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT
COBSCOOK & PASSAMAQUODDY BAYS
MAINE AND NEW BRUNSWICK

Prepared By
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30 November 1976
Revised 29 April 1977

FOREWORD TO THE OVERALL REPORT

In reviewing this report, the reader is advised that the report was prepared in two phases. The basic report of 30 November 1976 is an economic update of the International Passamaquoddy Tidal Power Project and is considered the first phase of effort. During the latter stages of the initial phase, two additional items were recommended to be addressed, namely: The feasibility of All-American tidal power concepts which would be entirely within the United States and analyzing tidal power on a life-cycle costing basis. The results of this second phase of study are included in the attached yellow pages Supplement dated 29 April 1977.

In summary, the results of the economic update on tidal power projects in the Passamaquoddy region are as follows:

a. The two pool International Passamaquoddy Tidal Power Projects, as described in the 30 November 1976 report, are not considered economically feasible since the Benefit-Cost Ratio is less than unity, specifically .53 to 1.00 and .49 to 1.00 for the 500 and 1000 Megawatt size plants respectively when only power benefits are considered. The Benefit-Cost Ratio increases to .74 to 1.00 and .67 to 1.00 for the 500 and 1000 Megawatt plants respectively when ancillary benefits of area redevelopment, fisheries-mariculture and recreation are included.

b. The various single and double pool All-American tidal plans as described in the Supplement are also not economically feasible when based on the conventional method of analysis. The Benefit-Cost Ratios vary between .31 and .45 to 1.0 when only the power benefits are considered. The range of Benefit-Cost Ratio increases to .55 and .77 to 1.00 when area redevelopment, fisheries-mariculture and recreation are incorporated as benefits.

c. The life-cycle economic evaluation by the Corps and Federal Power Commission of the 500 Megawatt international tidal power plan shows that the power benefits would exceed costs over the 100 year life span of the project. In a separate concurrent and coordinated tidal power study, the Energy Research and Development Administration analyzed some All-American concepts by life-cycle and considered the projects economically feasible when evaluated by this method. It is recognized that life-cycle costing is not the acceptable method of evaluating water resource projects, however, in view of the current energy situation, it deserves consideration in determining the future of a tidal power project in the Passamaquoddy region.

powerhouse with the addition of a second 500 Megawatt powerhouse at a later date; approximately 7 miles of earth and rock-filled dams to contain a high and low pool in Passamaquoddy (101 square miles) and Cobscook Bays (41 square miles) respectively; 90 filling gates, 70 emptying gates, 4 navigation locks, and channel excavation. The Total Investment Cost for the initial 500 Megawatt project would be $1,775,254,000 and $2,802,751,000 for the 1000 Megawatt project. The costs for transmission of power into the New England Power Pool system are not included in these figures but have been included in the annual costs listed below.

The estimated annual gross energy generation from the 500 Megawatt plant is 1,932 million kilowatt-hours and 2,360 million kilowatt-hours for the 1000 Megawatt plant.

Aside from the principal power benefits, there would be benefits from area redevelopment, fishing (mariculture) and recreation. An analysis of the economic factors was made with respect to annual benefits and costs of the project and a summary is as follows:

	Annual Benefits	Annual Costs	Benefit to Cost Ratio
500 MW Project	$ 89,674,000	$121,121,000	.74 to 1.00
1000 MW Project	$130,447,000	$193,739,000	.67 to 1.00

In view of the fact that the Benefit to Cost Ratio for both projects is below unity, it appears that further study of the International Passamaquoddy Tidal Power Project as conceived is not warranted. However, the tidal project does offer an opportunity to provide power,

SYLLABUS (OF BASIC REPORT)

The purpose of this feasibility report is to establish the economic feasibility of the International Passamaquoddy Tidal Power Project, Maine and New Brunswick under present conditions, and to determine if further studies on the project are warranted. Social and environmental impacts of the project were not a part of this effort and therefore are not discussed in this report. Such impacts are considered substantial and would be conducted if further study is accomplished.

The project has a long history dating back to the 1920's and was submitted to Congress for authorization in 1965, but authorization was not given because of economic infeasibility. However, New England is an area where residents pay among the highest prices in the country for electric power - primarily due to the region's dependence on foreign oil imports. This situation has become compounded dramatically in recent years as a result of the 1973-74 "oil embargo" and economic impacts on the region have been depressive. In 1975, a resolution was adopted by the U.S. Senate directing the New England Division, Corps of Engineers to conduct this study.

The tidal power project evaluated is that as proposed by the International Passamaquoddy Engineering Board in October 1959 with subsequent modifications recommended by the Passamaquoddy-Saint John River Study Committee in August 1964.

The international project would utilize the predictable and renewable resource, namely tidewater, to generate electrical "peaking" power to serve the needs and enhance the economy of the inhabitants of the Canadian Maritime Provinces and New England States. The proposed concept involves the initial construction of a 500 Megawatt powerhouse with the addition of a second 500 Megawatt powerhouse at a later date; approximately 7 miles of earth and rock-filled dams to contain a high and low pool in Passamaquoddy (101 square miles) and Cobscook Bays (41 square miles) respectively; 90 filling gates, 70 emptying gates, 4 navigation locks, and channel excavation. The Total Investment Cost for the initial 500 Megawatt project would be $1,775,254,000 and $2,802,751,000 for the 1000 Megawatt project. The costs for transmission of power into the New England Power Pool system are not included in these figures but have been included in the annual costs listed below.

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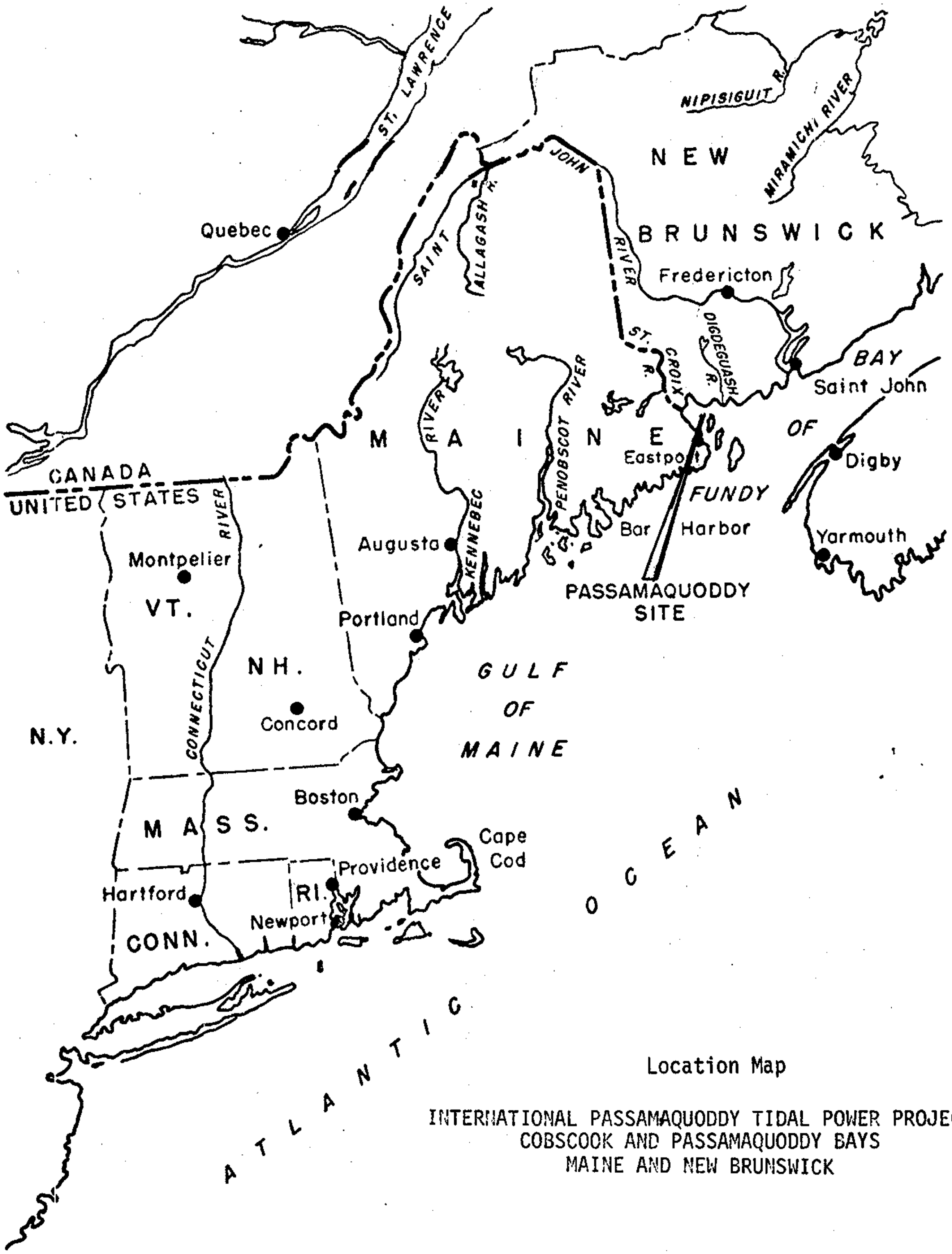
In view of the fact that the Benefit to Cost Ratio for both projects is below unity, it appears that further study of the International Passamaquoddy Tidal Power Project as conceived is not warranted. However, the tidal project does offer an opportunity to provide power, conserve natural resources equivalent to approximately 2,700,000 barrels of oil per year, alleviate future energy problems, and meet objectives of the New England Federal Regional Council.

It is felt that including conservation of natural energy resources as a "benefit" in the benefit-cost analysis should be worthy of further analysis. This savings has merit and increases the desirability of the project.

Our initial task to determine the economic feasibility of the international project is contained herein. However, during the latter stages of the economic investigation of the project, this Division received a letter from Honorable James B. Longley, Governor of Maine, requesting that the project be evaluated on a "life-cycle costing" basis. In addition, inquiries were received pertaining to the feasibility of a smaller All-American tidal power plan, such as the one for which construction was started in 1935 but stopped in 1936. The attached report does not include these two additional items of work but it is our intention to address and report on them by April 1977. Therefore, this present report should be considered an interim report, just evaluating the international tidal power concept; and considered final when the two additional items are included in a supplemental document in April 1977.

Before a final decision is made on terminating or continuing studies on tidal power in the Passamaquoddy region, it is recommended that the decision be deferred until about April 1977, when results from the separate tidal power study by the Energy Research and Development Administration to be completed in early 1977, and investigations



Location Map

INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT
COBSCOOK AND PASSAMAQUODDY BAYS
MAINE AND NEW BRUNSWICK

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ECONOMIC FEASIBILITY STUDY
FOR
INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT
COBSCOOK & PASSAMAQUODDY BAYS
MAINE, U.S.A. AND NEW BRUNSWICK, CANADA

I. INTRODUCTION AND PURPOSE

The purpose of this report is to re-evaluate and determine the present economic feasibility of the International Passamaquoddy Tidal Power Project (CWIS #14023) in Cobscook and Passamaquoddy Bays, Maine and New Brunswick and to see if further study of the project is warranted. The project is founded on harnessing the power resulting from high tidal action (averaging about 18 feet) in the vicinity of the two bay areas; the power would be supplied to the New England region of the United States and the Maritime Provinces of Canada.

The economic update is based on the prevailing currency values, interest rates, labor and material costs in the United States as of 30 June 1976. This effort was conducted independently and without the participation of Canadian counterparts, or inclusion of Canadian monetary interest rates, labor and material costs, or benefit amounts. No effort was made to separate the costs chargeable to Canada and the United States or the project benefits which could be derived by each country. For this re-evaluation phase of the project, it was considered to be in the best interests to first determine if the project was economically feasible from a United States viewpoint before contacts, coordination and participation were requested of the Canadian officials.

In addition to current capital and annual cost estimates, this report includes estimates of project benefits and the resulting benefit-to-cost ratios which can be obtained from tidal power, area redevelopment, recreation and fisheries.

The report was prepared under the direction of the Division Engineer, U.S. Army Engineer Division, New England, Waltham, Massachusetts.

II. AUTHORITIES

The authority for this work is derived from:

a. Resolution adopted on 21 March 1975 by the Committee on Public Works, United States Senate, as sponsored by Edward S. Muskie, Senator from Maine.

b. Public Law 94-180, Public Works Appropriations Act for Fiscal Year 1976 approved on 26 December 1975.

III. SCOPE OF THE WORK

This report updates to 30 June 1976 levels the economics of the Passamaquoddy Tidal Power Project. The work principally involves:

a. Preparing up-to-date construction, and operation and maintenance cost estimates based on the concepts for 500 and 1000 Megawatt two-pool tidal power projects as presented in the August 1964 report titled: Supplement to July 1963 Report - The International Passamaquoddy Tidal Power Project and Upper Saint John River Hydroelectric Power Development. The upper Saint John River Hydroelectric Power Development (Dickey-Lincoln School Lakes) was authorized in 1965 and is considered an independent project and is therefore not reported in this document.

b. Reflecting the prevailing monetary interest rate of 6-3/8% for Civil Works Project.

c. Preparing up-to-date benefits for the project from power, area redevelopment, recreation and fisheries.

d. Preparing an analysis of the benefits and costs to determine if the project is economically feasible under present conditions and if further study and investigations are warranted.

IV. STUDY MANAGEMENT AND PARTICIPANTS

The work under this phase of study was accomplished by the following:

Participant	Assignment/Task
New England Division	
Engineering Division	Overall study management, coordination, technical input, report preparation and reviews.
Planning Division	Area Redevelopment, Recreational and Fisheries Benefits.
Real Estate Division	Prepare up-to-date costs for Lands and Damages.
Federal Power Commission	Power projections, benefits and costs of transmission.
Stone & Webster Engineering Corporation	Preparation of up-to-date Construction, and Operation and Maintenance Cost Estimates.

V. SUMMARY OF PREVIOUS PROJECT REPORTS AND COST ESTIMATES

Over the past 50-60 years, tidal power projects in the vicinity of Cobscook and Passamaquoddy Bays have been studied many times and varying construction and operational concepts have been proposed. For comparison purposes, the following brief information on the more important engineering reports is furnished.

A. <u>1935-1936 Tidal Power Project</u>

The 1935-1936 project identified as PLAN "D" - two dams were actually built and one dam partially completed before the project was stopped in 1936 due to lack of funds.

The plan was an "All American" single high pool concept, located entirely within the boundaries of the U.S. The project (Plan D) was approved and described in report dated January 1936 with a revised cost estimate dated 2 May 1936. Cobscook Bay was the high pool with water discharging through the powerhouse into Western Passage. (See attached plan).

The plan provided for five 10,300 HP vertical turbine/generators for a total of 62,500 KW by tidal power; and a 30,000 KW diesel auxiliary plant. The total estimated annual energy output was 262 million KWH. Plans called for the future addition of five 12,500 KW units.

The final estimated construction cost of 2 May 1936 was $37,985,000 and consisted of:

Powerhouse (Five-12,500 KW units) (one-way flow)

30,000 KW Diesel Auxiliary Plant

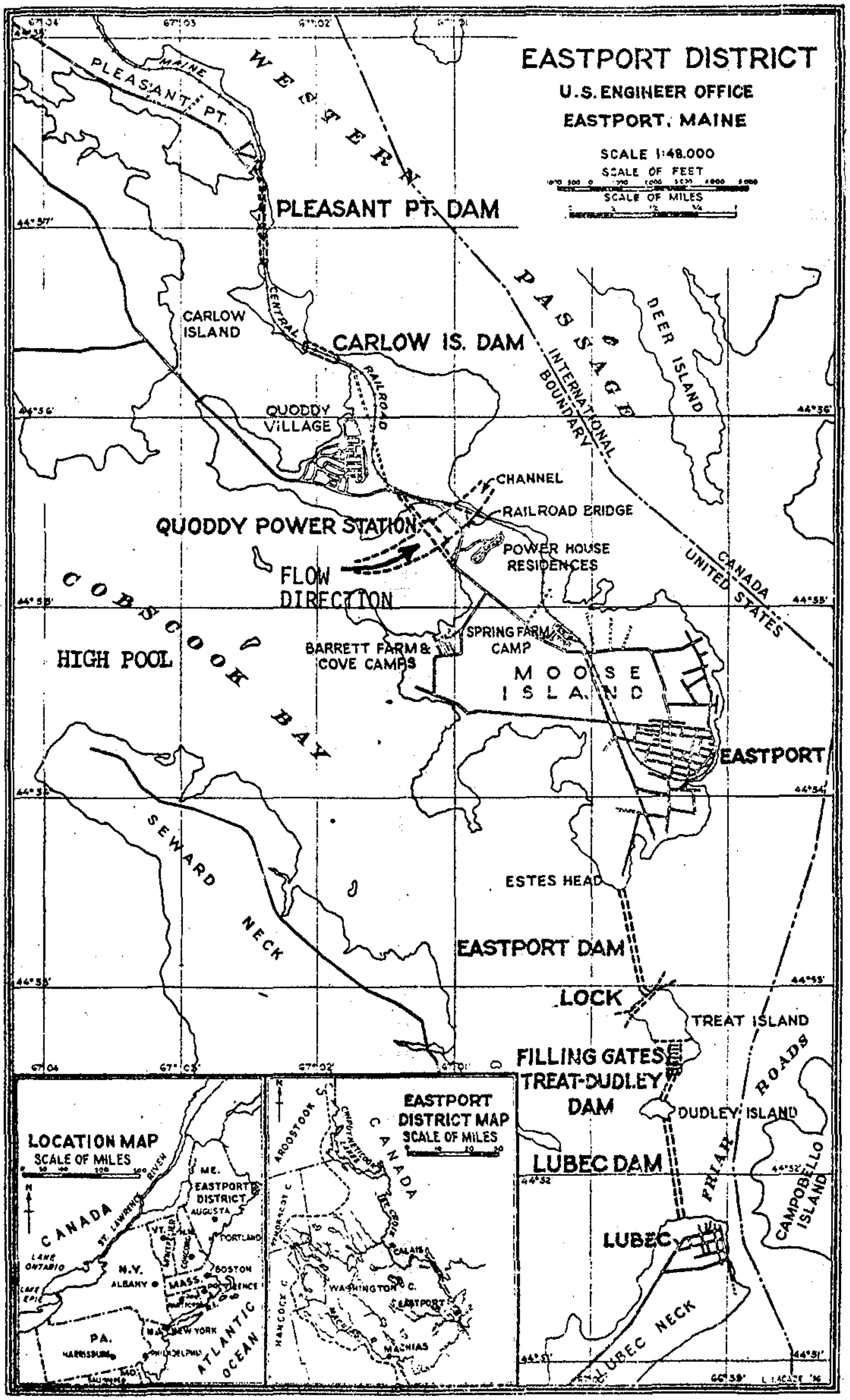
Filling gates (12 each on Treat Island)

Navigation Lock (56' x 360' on Treat Island)

Dams (5)

Carlow Island (completed)
Pleasant Point (completed)
Eastport (not started)
Treat-Dudley (started but not completed)
Lubec (not started)

Plate No. 1 shows the project layout.



PASSAMAQUODDY TIDAL POWER PROJECT

PLAN D - JAN. 1936

PLATE NO. 1

B. <u>The October 1959 Report</u>

In October 1959, The International Passamaquoddy Engineering Board prepared a report titled: "Investigation of the International Passamaquoddy Tidal Power Project." The project had identical facilities as described in Paragraph VI, Paragraph A herein except that the power-plant included thirty 10,000 KW vertical type units for a total of 300 MW. The average energy generation for the tidal project would be 1,843 million KWH a year. The reported estimated total investment cost for the 300 MW project was $532,100,000 including interest during construction. The annual costs were estimated to be $23,580,000. Benefit-to-cost ratios would have been as follows:

	Amortization Period*			
	50 years		100 years	
	U.S.	Canada	U.S.	Canada
Benefit-to-Cost Ratio	0.60	0.34	0.70	0.37
At-Site Cost of Energy (Mills/KWH)	10.8	14.9	9.3	13.7

*Based on 2½% interest in U.S. and 4-1/8% interest rate in Canada.

In addition to tidal power facilities, this report contained provisions for auxiliary hydropower at Rankin Rapids, Maine and a pumped storage plant at Digdeguash, New Brunswick.

C. <u>The April 1961 Report</u>

In April 1961, a report titled: <u>"Report of The International Joint Commission on The International Tidal Power Project"</u> (Docket 72) was prepared. The construction first cost used in this report was identical to the estimate contained in the October 1959 report. The project elements were the same as the October 1959 report.

D. The July 1963 Report

In July 1963, the report titled: "The International Passamaquoddy Tidal Power Project and Upper Saint John River Hydroelectric Power Development" was prepared under the direction of the Department of the Interior.

This study was basically a review of the International Joint Commission plan for the Passamaquoddy Tidal Power Project, and the cost estimate used in the IJC report was utilized where possible. In those instances where variations were necessary, the revisions to cost estimates were prepared by the Bureau of Reclamation, Denver, Colorado.

The estimated costs, exclusive of interest during construction were $500,973,300 and $759,289,400 for the 500 MW and a 1000 MW installation.

This report recommended that the project provide a 1000 MW of capacity in two 500 MW powerhouses, inasmuch as the 1959 and 1961 reports provided for a 300 MW plant. The plant would have been basically used for producing peaking power (1,213 million KWH) and would have been integrated with the storage and hydroelectric power development in the upper St. John River.(Dickey-Lincoln School Lakes). The combined projects were considered feasible based on an interest rate of 2-7/8%, with a benefit-to-cost ratio of 1.27 to 1.00. The benefit-to-cost ratio for the tidal power project alone was 1.04 to 1.00.

E. The August 1964 Report

In August 1964, the Passamaquoddy-St. John River Study Committee prepared a report titled: "Supplement to July 1963 Report - The International Passamaquoddy TIDAL POWER PROJECT and UPPER SAINT JOHN RIVER Hydrcelectric Power Development". The project was identical to the 1959 report except that scoping studies were made for 300, 500, 700 and 1000 MW installations and slanted type units replaced vertical units from previous studies. The reported Total Investment costs including interest during construction for the tidal power project are as follows:

Plant Size (Installed Capacity)	Total Investment Cost
300 MW	$472,670,000
500 MW	569,121,000
700 MW	702,837,000
1000 MW	869,755,000

The report contains additional findings by the Corps and Department of Interior over the 1963 report. The plan would have been to provide an initial capacity of 500 MW and ultimately 1000 MW of peaking power for New England and New Brunswick. The power plant would have incorporated reversible features in the turbines which would enable the generating units to be operated as pumps during the periods of neap tides and, hence operate at full installed capacity whenever needed. This reversible feature causes an insignificant increase in the investment cost and in the cost of energy for pumping required to accomplish this improvement. The project could have been repaid, with interest at 3% within 50 years after each unit becomes revenue producing at the following rates:

Capacity	$19.75/KW year
Energy	3.0 mills/KWH

The tidal power plant would produce approximately 1,932 million KWH of energy annually exclusive of the Dickey-Lincoln School facilities in the upper St. John River.

The benefit-to-cost ratio for the 500 MW project was 1.04 to 1.00 utilizing a 3% interest rate and a 100-year life.

F. The 1965 Report

This report is titled: "Report to President Lyndon B. Johnson, Conservation of the Natural Resources of New England, The Passamaquoddy Tidal Power and Upper Saint John River Hydroelectric Development", dated July 1965 and was prepared and coordinated by the Department of the Interior.

This report commented on the 1964 report and did not agree with the stated benefit-to-cost ratio of 1.04 to 1.00. The initial 500 MW tidal power project was estimated to cost $586,000,000. Their new benefit-to-cost ratio was computed to be 0.86 to 1.00 for the tidal power project only.

In view of this, the report recommended that the associated Dickey-Lincoln School Lakes project on the upper St. John River be immediately authorized and constructed; that the Passamaquoddy tidal power project continue to be studied, re-examined, and possibly be redesigned taking full advantage of latest technological advances with possible reduction in capital costs.

G. The 1973 Report was an update of the economics of the 1964 report based on a 500 MW facility at Passamaquoddy. Utilizing U.S. Bureau of Reclamation Hydro Cost Indices, an interest rate of 5½%, and 100-year project life, the revised Total Investment was increased to $973,477,000. The Annual Charges for the tidal project were $56,522,000 and Annual Benefits were $41,329,000 resulting in a benefit-to-cost ratio of 0.7 to 1.0.

H. The 1974 Report

This report dated July 1974 was an economic update of the July 1973 report. The costs were escalated from 1973, and the interest rate was revised to 5-7/8%. The costs were increased using the U.S. Bureau of Reclamation, Hydro Cost Index. The Total Investment for the project increased to $1,072,000,000 with Annual Charges of $70,300,000 and Annual Benefits of $52,760,000 for a benefit-to-cost ratio of 0.75. A nearly 28% increase in benefits for the tidal project from the previous year - reflecting principally higher fuel costs for power generation - was offset by the combination of escalating construction costs, increased interest rate, and inclusion of $4,165,000 for additional transmission costs.

I. Summary of Benefit-to-Cost Ratios for the Project Studies

The following summarizes the history of benefit-to-cost ratios in various studies of the International Tidal Power Project:

HISTORY OF BENEFIT-COST RATIOS OF INTERNATIONAL PLAN

Study	Interest Rate	Project Life	Benefit-to-Cost* Ratio
Oct 1959	2-1/2% U.S.	50 yr (300 MW) 75 yr (300 MW)	0.60 0.70
	4-1/8% Canada	50 yr (300 MW) 75 yr (300 MW)	0.34 0.37
Apr 1961	(Same as October 1959 Report)		
July 1963	2-7/8% U.S.	100 yr (500 MW)	1.04
Aug 1964	3% U.S.	100 yr (500 MW)	1.04
July 1965	3% U.S.	100 yr (500 MW)	0.86
July 1973	5-1/2% U.S.	100 yr (500 MW)	0.70
July 1974	5-7/8% U.S.	100 yr (500 MW)	0.75
Nov 1976	6-3/8% U.S. 6-3/8%	100 yr (500 MW) 100 yr (1000 MW)	0.74 0.67

* Passamaquoddy Tidal Power Project alone. Auxiliary facilities such as Dickey-Lincoln School and Rankin Rapids are not included.

J. Other Tidal Power Studies

1. Three other studies on tidal power are currently in progress and are as follows:

a. ERDA Tidal Power Study

In April 1976 the U.S. Energy Research and Development Administration (ERDA) awarded a contract in the amount of $168,733 to the Stone & Webster Engineering Corporation to study tidal power technology worldwide and to determine if more research might result in improvements of the economic competitiveness of tidal power plants. In addition the firm was commissioned to assess the feasibility of tidal power projects at Maine's Passamaquoddy Bay, Cook's Inlet near Anchorage, Alaska and other United States sites where the tides might be harnessed to generate electricity.

The contract work is to be completed in nine months in early 1977 and is being accomplished concurrently with the Corps study.

During the preliminary negotiation stages of the separate Corps and ERDA studies, coordination was made between the agencies to avoid duplication and to share information. The Corps study is different from the ERDA effort, in that the Corps reviewed and prepared up-to-date cost and benefit estimates, as well as determined the current economic feasibility of the specific tidal power project as proposed by the Passmaquoddy-St. John River Study Committee in August 1964 with changes thereto.

b. Tidal Power Studies by Canada

The possible use of the Bay of Fundy tides (as high as 53 feet) to produce electric power is being seriously considered by Canada. A new $3,000,000 survey of potential dam sites in the upper bay, sponsored by the Canadian Federal Government and the affected provinces of New Brunswick and Nova Scotia will be completed about February 1978. This effort is not evaluating the Passamaquoddy region.

According to preliminary assessments, a complex of dams in the upper bay could be developed including 13,000 megawatts of hydro-electric capacity.

Coordination was not pursued with the Canadian entities during this phase of updating the economics of the Passamaquoddy project.

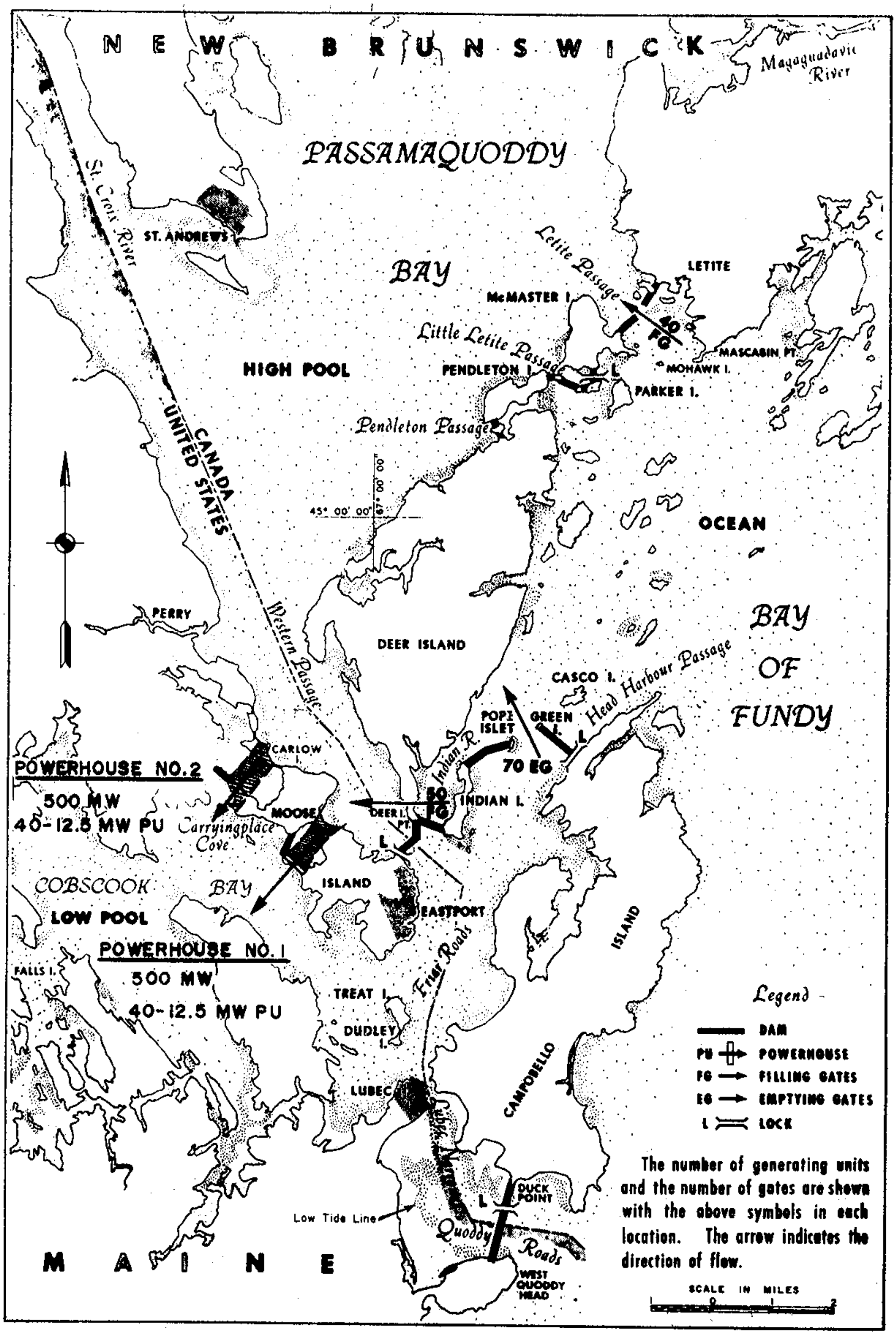
c. Another study on the economic feasibility of tidal power in the Passamaquoddy area is being accomplished by the Office of Technical Assessment, United States Congress. This study is to be completed in latter 1977.

VI. DESCRIPTION OF THE TIDAL POWER PROJECT

A. Project Facilities

The "Tidal Power Project Plan", Plate No. 2, shows the project area and location of major features.

In general, the project contains approximately seven miles of rock and earthfilled dams in waters up to 300 feet deep, four navigation locks, 90 filling gates, 70 emptying gates, a powerhouse of 500 MW and plans for addition of a second 500 MW powerhouse. Numerous natural islands form part of the barrier system separating the high and low pools, bays and the ocean from each other. The overall length of the entire project is approximately 20 miles.



TIDAL POWER PROJECT PLAN 6/15/76

(International Passamaquoddy Tidal Power Project)

PLATE NO. 2

The major facilities in the proposed tidal power project for which cost estimates are being prepared are as follows:

Item	Size
Power plant No. 1	500 MW (40-12,500 KW units)*
Power plant No. 2	500 MW (40-12,500 KW units)*
Switchyard	-
Letite Passage Filling Gates	40 ea (30'x30')
Western Passage Filling Gates	50 ea (30x'30')
Head Harbor Emptying Gates	70 ea (30'x30')
Head Harbor Passage Lock	415'x60'x21' draft
Western Passage Lock	415'x60'x21' draft
Little Letite Passage Lock	95'x25'x12' draft
Quoddy Roads Lock	95'x25'x12' draft

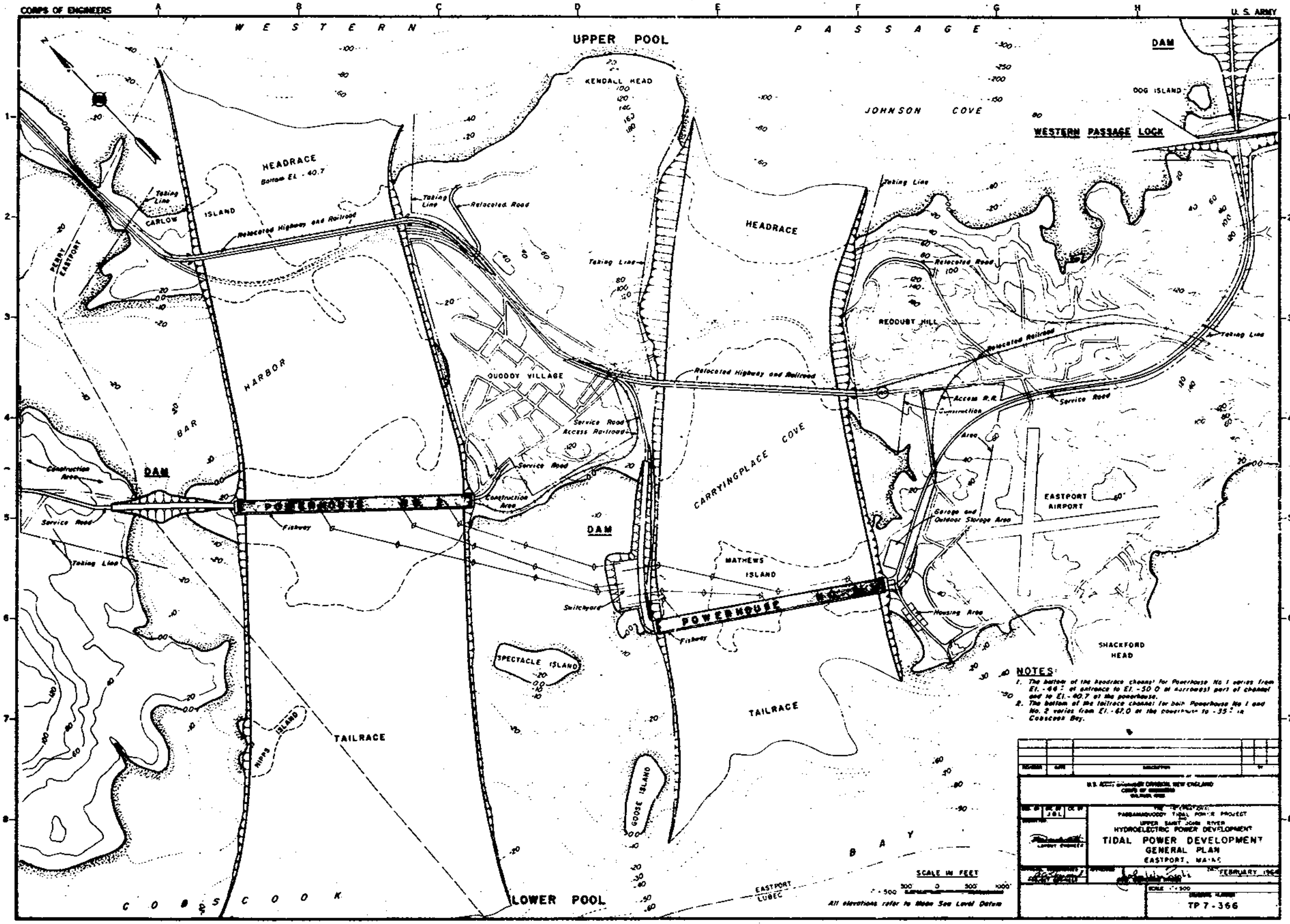
* Slant type turbine, generator and governor units.

Dams	
Letite Passage, North	approx. 0.50 miles long
Letite Passage, South	approx. 0.27 miles long
McMaster Is.-Jameson Is.	approx. 0.35 miles long
New Is.-Pendleton Is.	approx. 0.08 miles long
Pendleton Is.-English Is.	approx. 0.15 miles long
English Is.-Deer Is.	approx. 0.25 miles long
Head Harbor Passage, East	approx. 0.83 miles long
Head Harbor Passage, West	approx. 0.95 miles long
Indian River	approx. 0.4 miles long
Western Passage	approx. 0.7 miles long

Item	Size
Dams (Cont'd)	
Quoddy Roads	approx. 1.2 miles long
Carryingplace Cove	approx. 0.5 miles long
Bar Harbor	approx. 0.35 miles long
Lubec Channel	dredging 515,000 cy
Fishways	
Power plant No. 1	
Power plant No. 2	
Head Harbor Emptying Gates	
Service Facilities	
Relocations	
Lands and Damages	
Public Highways	

It is noted that the project does not provide for or include any auxiliary power facilities such as fossil fueled, pumped-storage or river hydro developments to integrate with the tidal power installation, all of which had been considered in the past.

Plate No. 3 shows the general plan of the powerhouse area with Powerhouse No. 1 being in Carryingplace Cove and Powerhouse No. 2 in the vicinity of Bar Harbor. The plan as shown is essentially as recommended in the August 1964 report, and the length of each powerhouse was about 3,486 feet long to provide for the fifty 10,000 KW slant-type units. With use of the forty 12,500 KW slant axis tube type units included in this economic update, the overall length of each powerhouse has been reduced to approximately 3,211 feet.



GENERAL PLAN - POWERHOUSE AREA

PLATE NO. 3

Plate No. 4 is a preliminary plan and section of a typical Main Unit Bay in the powerhouse for the 12,500 KW generation equipment.

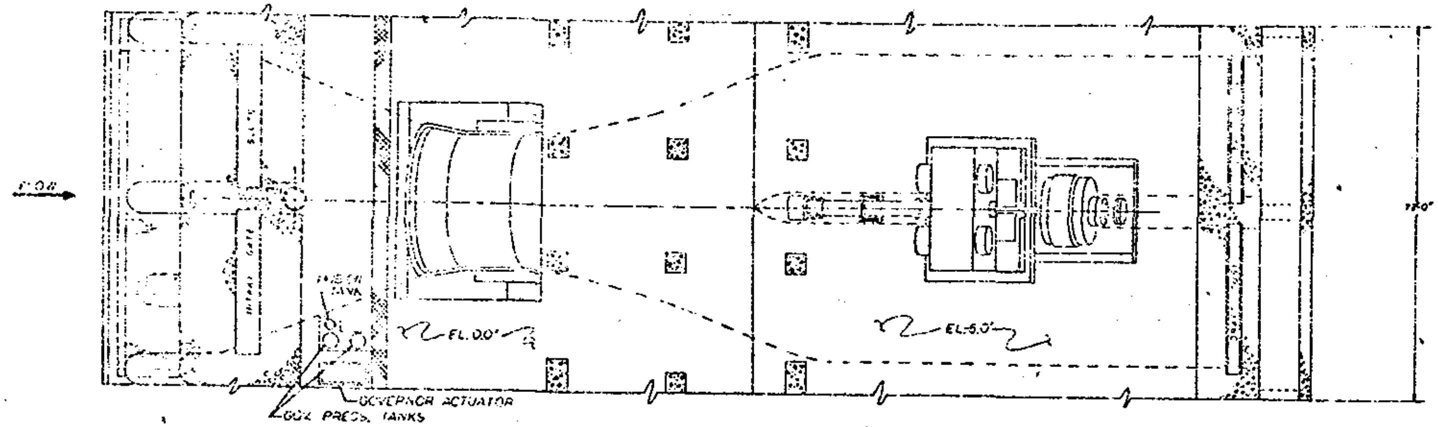
Exclusive of increasing the size of the generation equipment and decreasing the sizes of the powerhouses, there has been no other conceptual or design changes to the project since the August 1964 report. It is noted, however, that the construction area and access road and railroad have been adjusted from that as shown, so as to be compatible with a proposed oil refinery in the vicinity of the Eastport Airport.

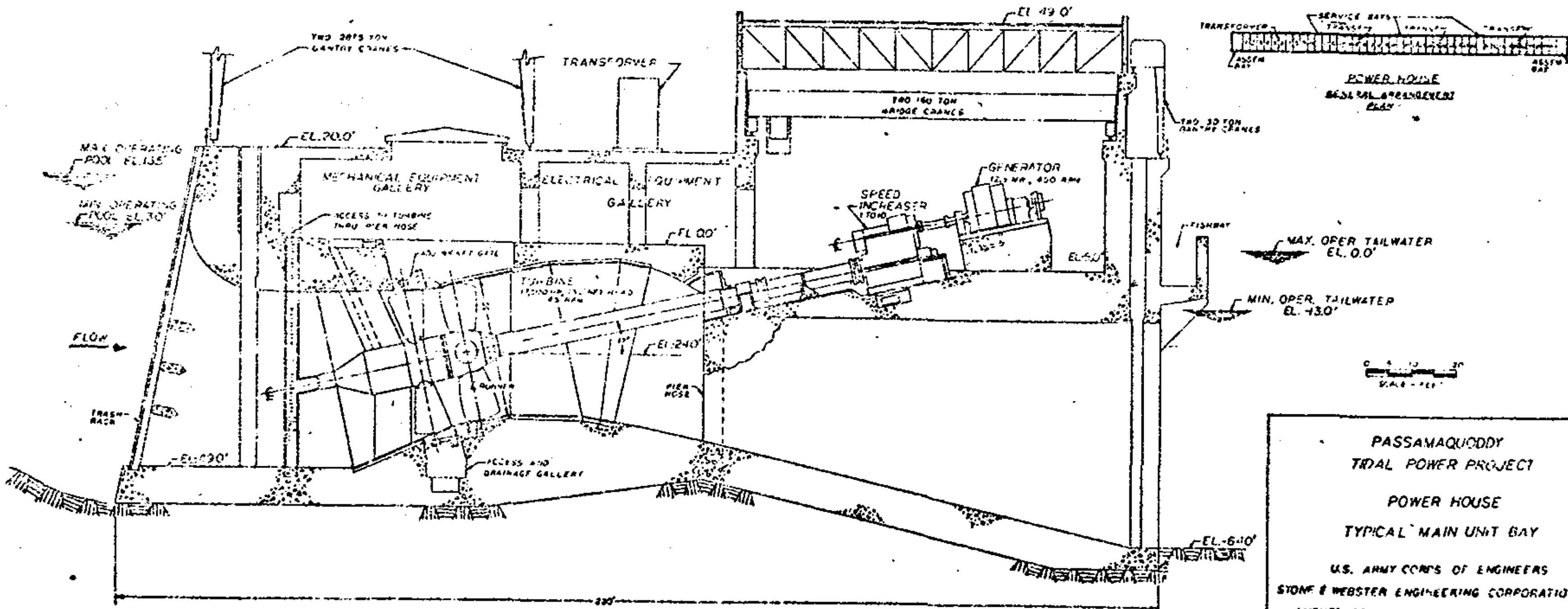
B. <u>Project Operational Characteristics</u>

1. <u>General</u>

The present cost estimate is based on a two-pool system in which Passamaquoddy Bay is the upper or high pool and Cobscook Bay is the so-called low pool. The water from the ocean and Bay of Fundy enters the high pool through ninety filling gates, passes through the powerhouses where electrical power is produced from the rotating turbines and generators, and is then discharged into the low pool. The lower bay is emptied into the ocean by seventy emptying gates. Passamaquoddy Bay is approximately 101 square miles and Cobscook Bay contains about 41 square miles. The power plant operates on a range of tides which varies from a minimum of 11.3 feet at neap tide to a maximum of 25.7 feet at spring tide or an average tide of 18.1 feet. The minimum operating head for the tidal power plant is about 6 feet.

Plate No. 5 is a schematic showing the release of stored flood tidewaters through the powerhouses and draining into the lower basin and back to the ocean. The filling gates to the upper basin are closed until the next incoming tide.





PASSAMAQUODDY
TIDAL POWER PROJECT

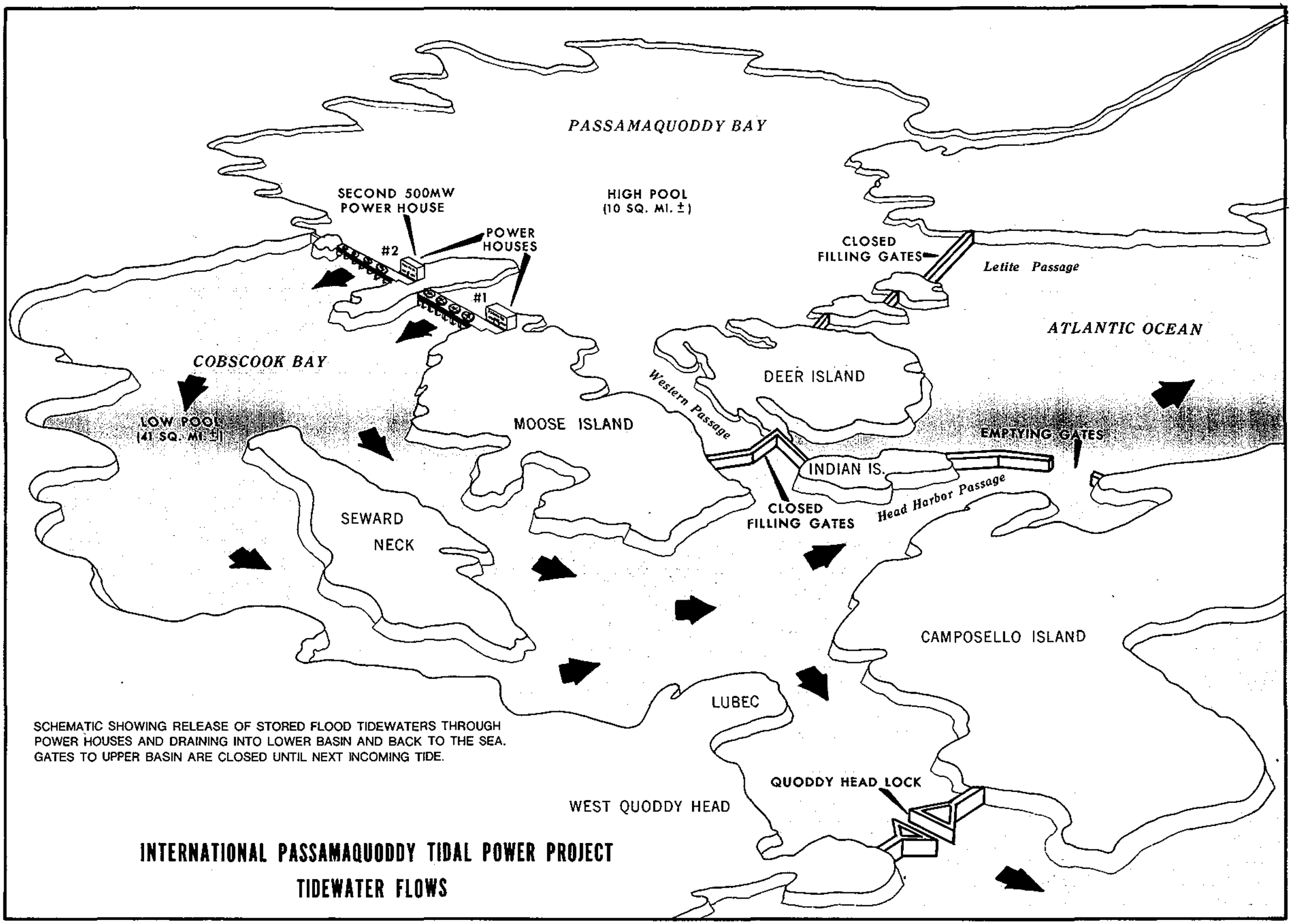
POWER HOUSE

TYPICAL MAIN UNIT BAY

U.S. ARMY CORPS OF ENGINEERS
STONE & WEBSTER ENGINEERING CORPORATION
AUGUST 23, 1976 J. O. 12797

PLATE NO. 4

PLATE NO. 5



SCHEMATIC SHOWING RELEASE OF STORED FLOOD TIDEWATERS THROUGH POWER HOUSES AND DRAINING INTO LOWER BASIN AND BACK TO THE SEA. GATES TO UPPER BASIN ARE CLOSED UNTIL NEXT INCOMING TIDE.

INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT
TIDEWATER FLOWS

By using reversible pump turbines, the difference between the water levels of the two pools can be increased during the neap tide beyond that obtainable from the tides alone. This increases the head available for generation of power during the neap tides. Thus, the Passamaquoddy power plant can be operated at the full installed capacity at the power plant during all peaking periods.

As noted, electric power generation would be the principal purpose of the Passamaquoddy Tidal Power Project. Many alternate facilities arrangements and concepts of operation are possible and have been reported in past studies. Project simulations of operation and power scoping are beyond the scope of this report, and therefore selection of a plan of development has been based on review of past reports. Power generation is essentially as indicated in the August 1964 supplement to the report "International Passamaquoddy Tidal Power Project and Upper Saint John River Hydroelectric Power Development", dated July 1963.

C. Generation

Energy output for the two sized power plants would be approximately as shown in Table 1.

TABLE 1

ENERGY PRODUCTION

Capacity (MW)	Energy (GWH/year)	Average Annual Capacity Factor (%)
500	1932	44.0
1000	2360	27.0

NOTE: 1 GWH = 1 Million kilowatt hours

As indicated in the previous section, pump turbines will be operated in pumping mode during neap tides with the objective of maintaining adequate head to develop generator nameplate in the next generating cycle. As pumping is accomplished at a lower head differential than the subsequent generation, there is actually an increase in energy realized from this operation. 33,997,000 KWH per year would be the required pumping energy, while 216,643,000 KWH per year would be realized in additional generation.

The project would have some flexibility in daily distribution of energy. Previous studies had considered full capacity peaking generation during a two-hour peak load period and maximization of energy generation during off-peak periods. Updated studies of project operation would be required to optimize more specifically energy distribution concepts. Not withstanding economics or operating plans, energy generation of two billion KWH per year from other sources would require over 2.7 million barrels of oil or one million tons of coal or 16.5 billion cubic feet of gas.

D. Reverse Pumping

1. Operation - Generation

The August 1964 supplement to the July 1963 report on The International Passamaquoddy Tidal Power Project and Upper Saint John Hydroelectric Power Development reported on utilizing reversible pump turbines in the tidal power project.

By using reversible pump turbines, the difference in water level between the high and low pools can be increased during the neap tide beyond that obtainable from the tides alone. This increases the head available for generation of power during the neap tides. Thus, the Passamaquoddy power plant can be operated at the full installed capacity during all peaking periods.

Based on an assumed 3-month period of 2 hour peaking duration and using forty 12,500 KW units (500 MW), 33,997 MWH of energy will be required for pumping. This in turn could produce 85,365 MWH during peaking periods or 216,643 MWH during off-peak periods. The foregoing are the estimated results of operation with pumping under the following conditions:

a. The low pool is drawn down during the low tide occurring before the peaking periods.

b. During the high tide preceding this low tide, the low pool is filled from the ocean and water pumped from the low pool to the high pool.

c. A 30% pumping efficiency has been assumed.

2. Construction Modifications

In order to provide for reverse pumping, changes in design and construction of the power plant would have to be accomplished by lowering the turbines and water passages about 5 feet. The 1964 report included this feature and the current updated Total Investment cost involved to lower the 40 units in one powerhouse is $38,575,000.

3. Economics

The justification of including the pumping feature at the Passamaquoddy Tidal Project is contained in the comparison of annual benefits derived from that feature as compared with the annual costs. Incremental annual costs of providing (and operating) the pump turbines as compared with conventional units are derived as follows:

<u>TOTAL INVESTMENT COSTS</u>	
Estimated Contract Cost (per powerhouse)	$26,147,000
Contingencies	<u>$ 2,950,000</u>
	$29,097,000
Engineering, Design, Supervision & Administration	<u>$ 2,037,000</u>
Project First Cost	$31,134,000
Interest During Construction	<u>$ 7,441,000</u>
Total Investment Cost	$38,575,000
<u>ANNUAL COSTS</u> - Includes	
Interest & Amortization	$ 2,464,000
Operation & Maintenance and Major Replacements	$ 165,000
Pumping Costs (33,997,000 KWH x $0.003)	<u>$ 102,000</u>
TOTAL ANNUAL COSTS	$ 2,731,000

The installation of the reverse pumping capability would permit the firming of 380,000 KW capacity and an annual energy gain of 85,365,000 KWH from the pumping operation. This annual benefit amounts to $19,149,000 which is included in the overall annual power benefits for the 500 MW plant and is broken down as follows:

Capacity

380,000 KW (500,000-120,000 KW) x \$45.00/KW = \$17,100,000

Energy

85,365,000 KWH x \$0.024/KWH = 2,049,000

\$19,149,000

In view of the fact that the reverse pumping component permits firming of the 500 MW capacity for 2-hour peaking power during neap tide periods and the benefits it contributes to the project, the installation of this capability is considered necessary.

VII. BASIS FOR PREPARATION OF ESTIMATED COSTS

The quantities, units and cost estimates for the Passamaquoddy Tidal Power Project as shown in the following reports were utilized as the bases of preparing the new updated estimates:

a. Report dated October 1959, entitled: Investigation of the International Passamaquoddy Tidal Power Project by the International Passamaquoddy Engineering Board.

b. Report dated August 1964, entitled: Supplement to July 1963 Report - The International Passamaquoddy Tidal Power Project and Upper Saint John River Hydroelectric Power Development by the Passamaquoddy-Saint John River Study Committee.

The quantities for the facilities contained in these two reports were unchanged except for the powerhouse structures. The unit prices, labor rates, equipment rates, production units, fringe benefits have been reviewed and revised on an individual basis. In some miscellaneous instances where the benefit of more detailed data was not available, estimates were based on experience, i.e. cost per square foot basis. Rarely was the item cost increased by using an escalation index such as ENR or U.S. Bureau of Reclamation Hydro Cost Index alone. For the larger items of installed equipment, contact was made with manufacturers for latest price quotations.

The estimated project first costs include contract costs, contingencies, engineering and design (E&D), supervision and administration (S&A). Interest during construction has been added to provide Total Investment for the project.

VIII. CRITERIA AND ASSUMPTIONS FOR PREPARING THE CONSTRUCTION AND OPERATIONAL MAINTENANCE COST ESTIMATES

The estimates are based on the following criteria:

1. The tidal power project concept (configuration of facilities) is the same as that shown in the 1964 Study Committee report.

2. The project financing is based on a 100-year life.

3. For this feasibility estimate, the costs are based on U.S. currency, wage rates and material costs as of 30 June 1976.

4. An annual interest rate of 6-3/8% for return on investment and interest during construction. The 6-3/8% interest rate has been retained in accordance with Engineer Circular 11-2-126 dated 20 July 1976. Such interest rate was effective 1 October 1976 for projects for which FY 1978 budget data is being submitted.

5. A construction contingency factor of 10% is used on all installed items of equipment, and a factor of 15% for all remaining work shall be utilized.

6. The allowance for Government costs which cover engineering and design (E&D), and supervision, inspection and administration (S&A) during construction has been analyzed, based and computed on estimated project needs in lieu of utilizing straight percentages.

7. It is estimated that one-quarter of major installed equipment will have to be replaced every 30 years.

8. The estimated life of the remaining project facilities is 100 years.

9. It is considered that the project will be totally federally funded and that there will be no non-federal investments.

10. The construction period is $7\frac{1}{2}$ years for the 500 MW project or $8\frac{1}{2}$ years for the 1000 MW plant.

11. Provisions for outside temporary camp and commissary for construction personnel have not been included in the cost estimate. In lieu of this, subsistence and/or traveling have been included in the crew labor rates.

12. The estimate is based on the following all year round work shifts:

a. Six day week - Three 8 hour shifts

Hydraulic dredging

Dipper dredge operations

Embankment work at dams

b. Six day week - Two 8 hour shifts

Earth and rock excavation in dry

Quarrying and crushing operations

Concrete mixing and placing operations

c. Five day week - Single 8 hour shift

All other activities

13. Construction methods, equipment, and materials proposed in the previous reports were reviewed and were judged to be generally the same as would be used today.

14. It is proposed for the updated estimate that excavation of impervious material from the powerhouse area for use in the dams would be by dipper dredge, rather than by hydraulic dredge as was previously proposed. The dipper dredge operation will result in less segregation of the material when placed in the dams and a better dam construction.

15. Labor rates are based on U.S. Department of Labor schedule for Washington County, Maine which expired in August 1976.

16. Equipment ownership and operating costs are from the Associated Equipment Distributors (AED) Book published in 1975 and marine equipment rates were taken from records maintained in this Division.

IX. ESTIMATED PROJECT COST

A. Construction Cost Estimates

1. General

The First Cost and Total Investment amounts for the 500 and 1000 MW projects are presented separately.

2. 500 MW Project

The basic project consists of one 500 MW Powerhouse No. 1 with dams, locks, filling and emptying gates, etc. A Total Investment cost estimate in the amount of $1,775,254,000 is prepared for this size of project and is included herein. This estimate includes 500 MW of reversible capacity.

3. 1000 MW Project

In the event the project is increased in size to provide for a second 500 MW power plant, additional costs are involved for the additional power plant, fishways, service facilities, relocations, lands and damages. A separate Total Investment cost estimate of $2,802,751,000 is prepared for this size of project and is included herein.

4. Estimates for Additional Items

a. Added Costs for Lowering Turbine Hub for Reverse Pumping

An estimate in the amount of $38,575,000 is provided to reflect the cost for lowering the turbine hubs to pump water from the low pool to the high pool so as to maintain higher head and additional water capacity for power production.

b. Cost Estimate for Public Highways

A separate Total Investment cost estimate of $26,908,000 is prepared for Public Highways which is considered an Additive Item. A breakdown of the estimate is included in Table 4.

c. Cost Estimate for Two Alternate Size Navigation Locks

In view of possible future navigational needs for larger locks, estimates are included for two alternate size navigation locks to the basic lock (415'x60'x21') at Head Harbor Passage. These two alternate lock sizes are:

Lock	Est. Total Investment Cost
830'x120'x42' draft	$ 86,443,000
1250'x180'x67' draft	$141,167,000

d. Cost Estimate for Large Alternate Lock at Little Letite Passage

A separate Total Investment cost in the amount of $56,063,000 (See Table 3) is prepared in the event a larger lock (800'x80'x30' draft) is planned in lieu of the basic lock (95'x25'x12') at Little Letite Passage.

Summaries of the estimates follow in Tables 2 and 3.

TABLE 2

SUMMARY

ESTIMATE OF COST (500 MW) PROJECT

PASSAMAQUODDY TIDAL POWER PROJECT
COBSCOOK AND PASSAMAQUODDY BAYS
MAINE AND NEW BRUNSWICK

Item No.	Item	Size	Cost
1.	Powerplant No. 1 (07)	500 MW	$628,930,000
2.	Switchyard (07.3)		5,556,000
3.	Letite Passage Filling Gates	40 ea	71,956,000
4.	Western Passage Filling Gates	50 ea	85,544,000
5.	Head Harbor Emptying Gates	70 ea	141,628,000
6.	Head Harbor Passage Lock (05)	415x60x21	17,608,000
7.	Western Passage Lock (05)	415x60x21	18,469,000
8.	Little Letite Passage Lock (05)	95x25x12	4,040,000
9.	Quoddy Roads Lock (05)	95x25x12	7,260,000
10.	Dams (04)		
	a. Letite Passage North	L.S.	1,266,000
	b. Letite Passage South	L.S.	7,398,000
	c. McMaster Is. to Jameson Is.	L.S.	1,897,000
	d. Jameson Is. to New Is.	L.S.	4,757,000
	e. New Is. to Pendleton Is.	L.S.	253,000
	f. Pendleton Isl. to English Is.	L.S.	884,000
	g. English Is. to Deer Is.	L.S.	726,000
	h. Head Harbor Passage, East	L.S.	57,281,000
	i. Head Harbor Passage, West	L.S.	35,419,000
	j. Indian River	L.S.	9,645,000
	k. Western Passage	L.S.	45,323,000
	l. Carryingplace Cove	L.S.	1,228,000
	m. Quoddy Roads	L.S.	14,754,000
	Sub-Total - Dams		$180,831,000
11.	Lubec Channel (09)	L.S.	1,613,000
12.	Fishways (06)		
	Powerplant No. 1	L.S.	2,217,000
	Head Harbor Emptying Gates	L.S.	863,000
	Sub-Total		$ 3,080,000
13.	Service Facilities (19)		
	For 500 MW Project	L.S.	3,711,000

TABLE 2 (Cont'd)

Item No.	Item	Size	Cost
14.	Relocations (02)		
	For 500 MW Project		
	a. In Canada	L.S.	266,000
	b. In United States	L.S.	13,680,000
	Sub-Total		$ 13,946,000
	Lands and Damages (01)		
	For 500 MW Project		
	a. In Canada	L.S.	$ 1,772,000
	b. In United States	L.S.	1,412,000
	Sub-Total		$ 3,184,000
	Sub-Total		$1,187,356,000
	Contingencies		$ 154,025,000
	Sub-Total		$1,341,381,000
	Engineering, Design, Supervision & Administration (30 and 31)		$ 91,431,000
	Total Project First Cost		$1,432,812,000
	Interest During Construction *		$ 342,442,000
	TOTAL INVESTMENT (500 MW)		$1,775,254,000

The above estimate includes the costs necessary for lowering the turbine hubs for reverse pumping capability.

*The preliminary amount for Interest During Construction (IDC) is computed utilizing the interest rate x one-half the construction period in years x the total estimated project cost. In general, IDC is the estimated accrued interest on project expenditures and values until the project services become available.

If a second 500 Megawatt Power Plant (Powerhouse No. 2) is added to provide a tidal power facility with 1,000 megawatts of installed capacity, the additional costs involved are shown on Table 2A.

It is noted that the system of dams, emptying-filling gates and navigational locks do not have to be increased or modified if the facility is increased to 1,000 megawatt capacity.

TABLE 2A

ESTIMATED ADDITIONAL COSTS FOR POWERHOUSE NO. 2

Total Investment Cost (Initial 500 MW):		$1,775,254,000
Additional Costs for 2nd 500 MW Plant:		
Powerplant No. 2	$637,565,000	
Switchyard	5,980,000	
Service Facilities	903,000	
Fishways	2,217,000	
Land and Damages	890,000	
Relocations	13,862,000	
Sub Total	$661,417,000	
Contingencies	80,827,000	
Sub Total	$742,244,000	
Engineering, Design Supv. & Admin.	30,882,000	
Total Project First Cost	$773,126,000	
Interest During Construction	$254,371,000	
Total Investment Cost for 2nd 500 MW Plant		$1,027,497,000
Total Investment Cost (1,000 MW)		$2,802,751,000

Table 3 presents the estimated costs of the complete 1,000 megawatt tidal power project.

TABLE 3

SUMMARY

ESTIMATE OF COMPLETE COSTS OF (1,000 MW) PROJECT
PASSAMAQUODDY TIDAL POWER PROJECT
COBSCOOK AND PASSAMAQUODDY BAYS
MAINE AND NEW BRUNSWICK

Item No.	Item	Size	Cost
1.	Powerplants (07)		
	a. Powerplant No. 1	500 MW	$ 628,930,000
	b. Powerplant No. 2	500 MW	637,565,000
	Sub-Total	1000 MW	$1,266,495,000
2.	Switchyard (07.3)	L.S.	$ 11,536,000
3.	Filling Gates	90 ea	$ 157,500,000
4.	Emptying Gates	70 ea	$ 141,628,000
5.	Locks (4 ea) (05)	L.S.	$ 47,377,000
6.	Dams (04)	L.S.	$ 180,831,000
7.	Lubec Channel (09)	L.S.	$ 1,613,000
8.	Fishways (06)	L.S.	
	a. For 500 MW Project	L.S.	$ 3,080,000
	b. For 500 MW Addition	L.S.	$ 2,217,000
	Sub-Total		$ 5,297,000
9.	Service Facilities (19)		
	a. For 500 MW Project	L.S.	$ 3,711,000
	b. For 500 MW Addition	L.S.	$ 903,000
	Sub-Total		$ 4,614,000
10.	Relocations (02)		
	a. For 500 MW Project		
	In Canada	L.S.	$ 266,000
	In United States	L.S.	13,680,000
			$ 13,946,000

Table 3 (Cont'd)

Item No.	Item	Size	Cost
	b. For 500 MW Addition		
	In Canada	L.S.	$ -
	In United States		$ 13,862,000
	Sub-Total		$ 27,808,000
11.	Lands and Damages (01)		
	a. For 500 MW Project		
	In Canada	L.S.	$ 1,772,000
	In United States	L.S.	$ 1,412,000
	b. For 500 MW Project		
	In Canada	L.S.	$ -
	In United States	L.S.	$ 890,000
	Sub-Total		$ 4,074,000
	Sub-Total		$1,848,773,000
	Contingencies		$ 234,852,000
	Sub-Total		$2,083,625,000
	Engineering & Design, Supervision & Administration (30 & 31)		$ 122,313,000
	Total Project First Cost		$2,205,938,000
	Interest During Construction		$ 596,813,000
	TOTAL INVESTMENT (1000 MW)		$2,802,751,000

The above estimate includes the costs necessary for lowering the turbine hubs for reverse pumping capability.

All costs are based on price levels of 30 June 1976.

TABLE 4

SUMMARY

ESTIMATE OF COST (ADDITIONAL ITEMS)
PASSAMAQUODDY TIDAL POWER PROJECT
COBSCOOK AND PASSAMAQUODDY BAYS
MAINE AND NEW BRUNSWICK

NCTE: These items are included for informational purposes in the event they are added to the project.

Public Highways*

In United States	L.S.	$ 1,967,000
Contingencies		295,000
Sub-Total		$ 2,262,000
Engineering, Design, Supervision & Administration		$ 203,000
TOTAL Sub-Item First Cost		$ 2,465,000
In Canada	L.S.	$ 14,893,000
Contingencies		2,256,000
Sub-Total		$ 17,149,000
Engineering, Design Supervision & Administration		$ 1,556,000
TOTAL Sub-Item First Cost		$ 18,706,000
TOTAL Item First Cost in United States and Canada		$ 21,171,000
Interest on Construction		$ 5,737,000
TOTAL Item Investment		$ 26, 908,000

Alternate Future Navigation Locks** (Head Harbor Passage)

Lock	830x120x42	$ 56,287,000
Contingencies		$ 7,936,000
Sub-Total		$ 64,223,000
Engineering, Design Supervision & Administration		$ 3,789,000

TABLE 4 (Cont'd)

TOTAL Item First Cost		$ 68,012,000
Interest During Construction		$ 18,431,000
TOTAL Item Investment		$ 86,443,000
Lock	1250x180x67	$ 92,000,000
Contingencies		$ 12,880,000
Sub-Total		$ 104,880,000
Engineering, Design, Supervision & Administration		$ 6,188,000
TOTAL Item First Cost		$ 111,068,000
Interest During Construction		$ 30,099,000
TOTAL Item Investment		$ 141,167,000
Alternate Future Navigation Lock (Little Letite Passage)	(800'x80'x30' draft)	$ 36,537,000
Lock Contingencies		$ 5,115,000
Sub-Total		$ 41,652,000
Engineering, Design, Supervision & Administration		2,457,000
TOTAL Item First Cost		$ 44,109,000
Interest During Construction		11,954,000
TOTAL ITEM INVESTMENT		$ 56,063,000

*The cost of the Public Highways is for a road system connecting Route 1 at St. George, New Brunswick to Route 189 at Lubec, Maine. The cost includes necessary construction on the dams and gates of the tidal project, as well as connecting roads over the land where no project construction is involved. No specific studies have been made to determine whether the cost could be justified or not, nor are the public highway costs included in the cost for power.

5. Items Not Chargeable to Project Power

Construction of the following items are not chargeable to the project power:

Item	Comments
Family Quarters (10 units for key personnel)	Although the cost of housing is in the project first costs, rent payments would be set to make the investment in housing self-liquidating and the cost would not appear in the project power costs.
Public Highways	The tidal dams and structures afford a good opportunity for connecting the mainland and islands by public highways. For the purposes of this estimate, it was assumed that the public highways would be constructed complete in lieu of service roads charged to tidal power. Therefore, the cost of the public highways not charged to tidal power would be the difference between the total cost of the public highways and the total cost of the service roads.

Note: During the 1956-1959 study it was noted that in the event the future larger navigational locks were built at Little Letite Passage and Head Harbor Passage the additional costs would be borne by Navigation and not Power. However, during the course of this current economic update it has been determined that the additional costs required for larger navigation locks will have to be charged against the project and power.

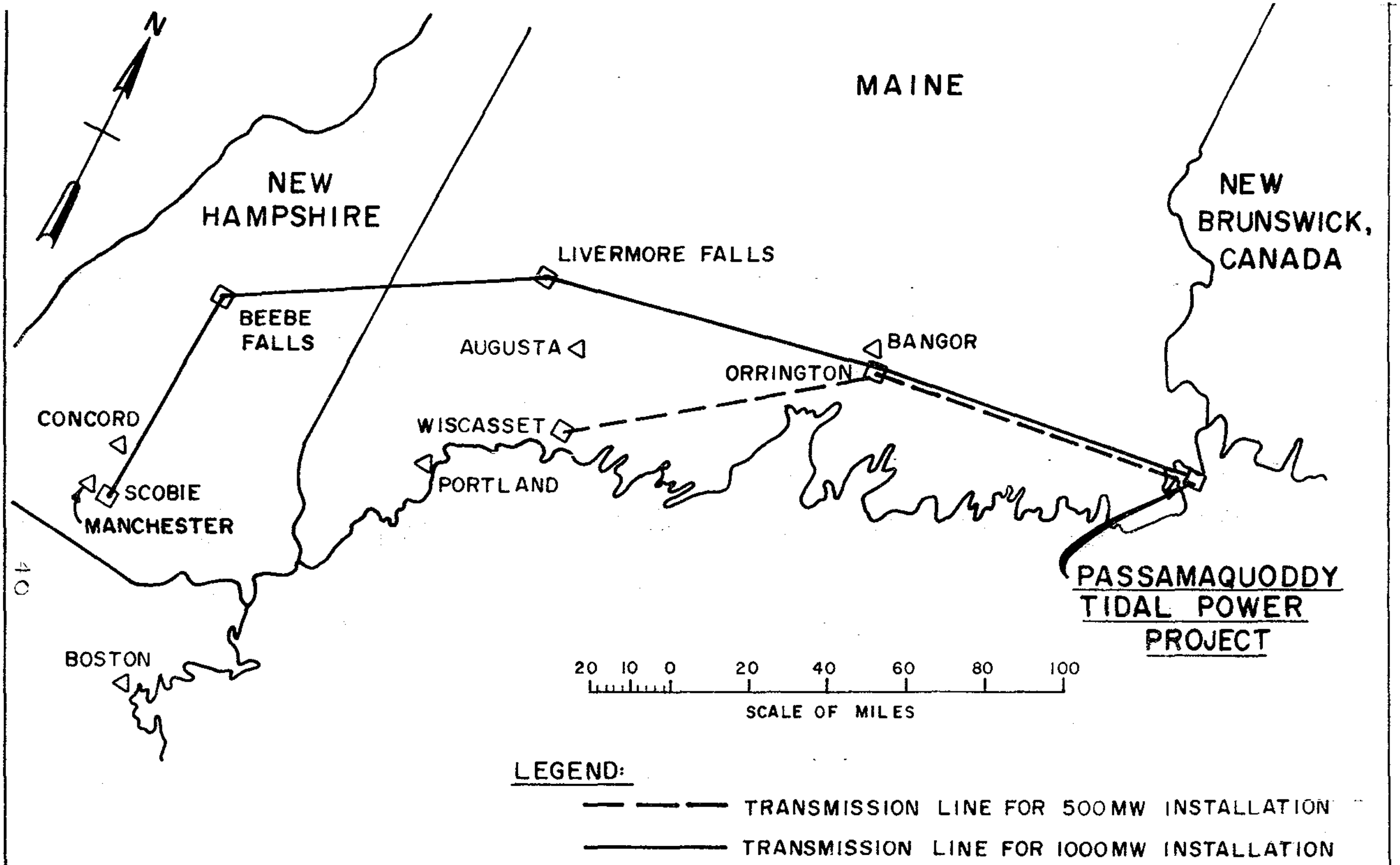
6. Transmission of Power

a. Preliminary plans and cost estimates for the transmission of electric power from the project site to the nearest feasible point of connection to the New England Power Pool System were developed by the Federal Power Commission, New York Regional Office.

b. Although the international tidal plan previously envisioned the power being divided equally between Canada and the United States, for cost estimating purposes, the assumption used in this report is based on all power and transmission going to points in the United States.

c. In reference to the transmission system, the following excerpts are taken from a Federal Power Commission letter dated 12 August 1976:

"Project transmission requirements were based on consideration of projected power flows on the NEPOOL system and the proposed development at Quoddy and an assumption that Dickey-Lincoln School and associated transmission would be in service. For the initial 500 MW installation, two 345 KV outlets were assumed - one to the existing Orrington 345 KV switching station near Bangor (85 miles), and another to the existing Maine Yankee 345 KV switchyard at Wiscasset, Maine. The estimated cost of transmission for this scheme was about $48,500,000.



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PASSAMAQUODDY TIDAL POWER PROJECT

OCT. 1976

PLATE NO. 6

For the 1000 MW installation, the Quoddy-Maine Yankee 345 KV circuit was looped through an expanded Orrington switching station, and a 345 KV line was added from Orrington to a new substation in the Livermore Falls, Maine area, thence to an assumed Beebee, New Hampshire termination of the Dickey-Lincoln School transmission, and to the eixsting Scobie 345 KV substation near Manchester, New Hampshire. Total cost of required transmission for the 1000 MW proposal was estimated at about $110,000,000."

Plate No. 6 is a sketch showing the approximate locations of the transmission lines.

7. Summary of Total Investment Costs

The total investment costs are:

Item	Size Facility 500 MW	Size Facility 1000 MW
Tidal Power Project	$1,775,254,000	$2,802,751,000
Transmission	54,683,000	124,025,000
Total Investment Cost for Overall Project	$1,829,937,000	$2,926,776,000

B. Tidal Power Development Schedule

The construction period for the 500 MW project, including a single powerhouse with 40 units, would be 7½ years from the start of temporary construction facilities to the completion of final operational testing of the turbine-generator units. The proposed detailed construction schedule, for the 500 MW project, is shown on Plate No. 7

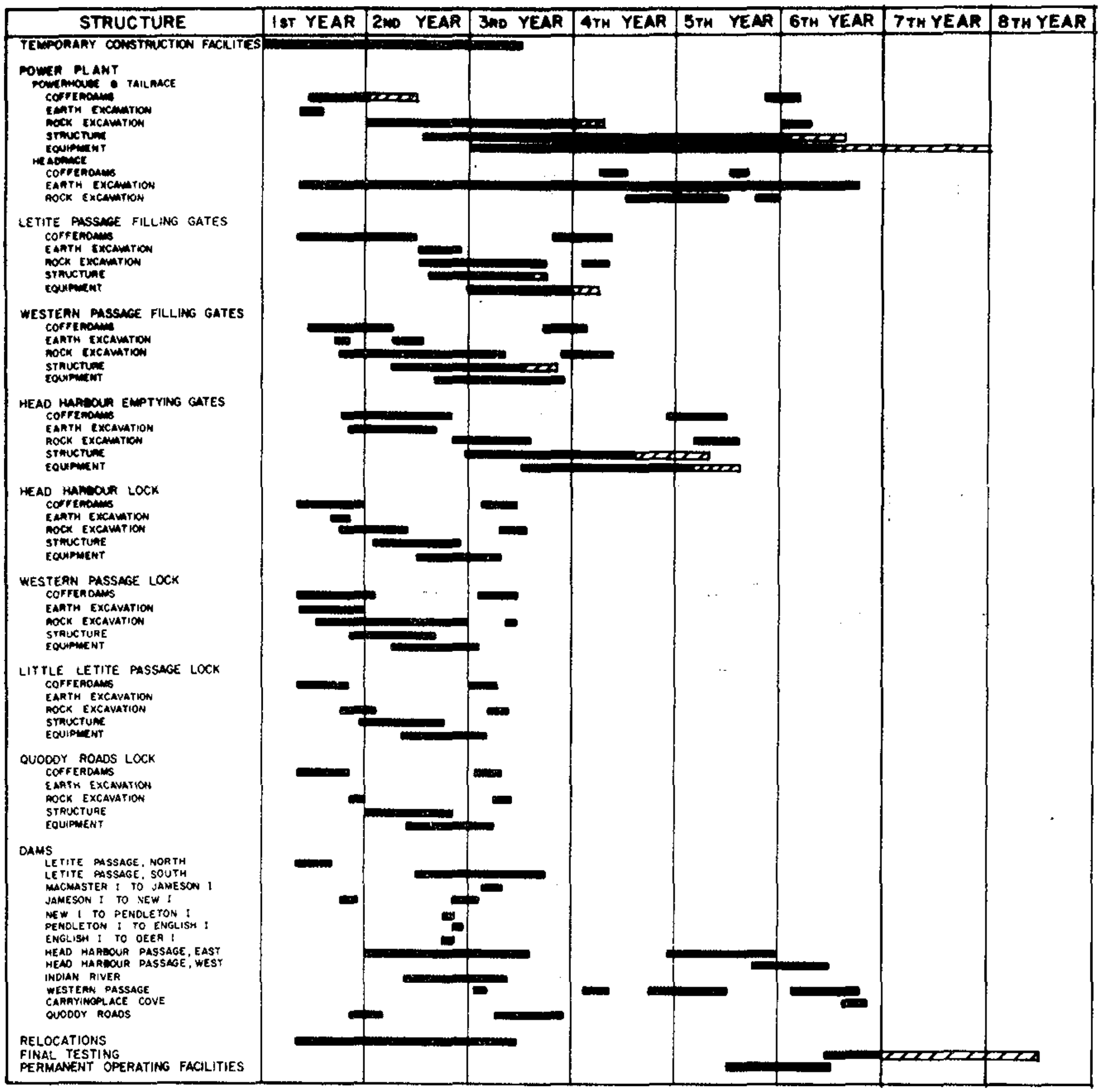
Plate No. 7a shows the proposed schedule for construction of the second 40 unit 500 MW power plant. The total construction period for this facility is also 7½ years. Although this schedule has been shown separate and unrelated to the schedule for the first power plant and the other project facilities, it has been assumed for purposes of estimating interest during construction that the second power plant would be started one year after the start of the first powerhouse and completed one year after completion of the 500 MW project. Therefore, the construction period for the total 1000 MW project would be 8½ years.

Dredging and material placement in the dams would be continuous, 24 hour operations for six days per week. Other activities, such as equipment installation work, would be on a single 8 hour shift, five days per week. It has been assumed that the main turbine-generator units can be completed at the average rate of one per month.

Construction of the tidal power project would require work during the full year. Delays such as cessation of water transportation during heavy fog and of placing concrete in freezing weather due to weather would occur. These delays have been accounted for in the schedule and an allowance included in the cost estimates.

Advance procurement of equipment and preparation of equipment design drawings are necessary for timely completion of project.

CONSTRUCTION SCHEDULE



= 1964 SCHEDULE

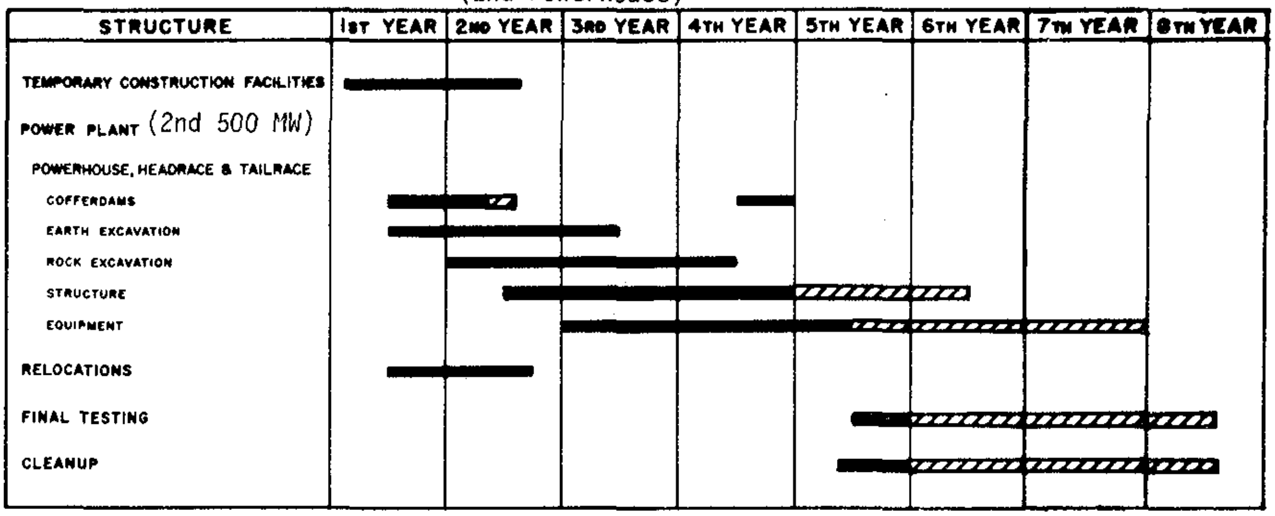
= REVISION TO 1964 SCHEDULE

PASSAMAQUODDY
TIDAL POWER DEVELOPMENT
CONSTRUCTION SCHEDULE (500 MW)
POWERHOUSE NO. 1 - 40 UNITS
REVISED 31 AUG 1976 T67-371

PLATE NO. 7

SCHEDULE I

CONSTRUCTION SCHEDULE
(2nd Powerhouse)



= 1964 SCHEDULE

= REVISION TO 1964 SCHEDULE

PASSAMAQUODDY
TIDAL POWER DEVELOPMENT
CONSTRUCTION SCHEDULE
POWERHOUSE NO.2-40 UNITS

REVISED 31 AUG 76 T67-372

PLATE NO. 7a

SCHEDULE 2

The tidal project can be easily divided into separate contracts of reasonable size and duration for the following reasons: (1) the work can be handled by individual contractors or combines without fear of a great change in price level during their work period, and (2) to assure competition for bidding. Close coordination of the excavations would be needed, especially where rock, sand, gravel and clay from one excavation produces cofferdam material for another area and where the excavated material is used in the tidal dams.

The powerhouse would take the longest time to complete. To make an early start, the material to build the powerhouse cofferdams would be borrowed.

The schedule of construction of the various emptying and filling gates is based on working on all three sites at the same time. After placement of about one-third of the concrete, one gate a week including its equipment, would be installed per week. In this way, the filling gates at Letite and Western Passage would be completed by about the middle of the fourth year, and the Head Harbor Passage emptying gates would be completed by about the middle of the fifth year.

The construction of the locks would take 2½ years and would be scheduled to be completed before the tidal dams were closed, so that normal and construction traffic could be maintained in the bay area.

C. Project Annual Costs

1. Estimate

The estimated total annual costs for the 500 MW and 1000 MW projects are $121,121,000 and $193,739,000, respectively. A breakdown of these estimates is shown in Table 5. Annual interest and amortization

TABLE 5

PROJECT ANNUAL COSTS
(June 1976 Price Levels)

	500 MW Project	1000 MW Project
Total Investment-Tidal Project		
Construction Cost	$1,432,812,000	$2,205,938,000
Interest During Construction	342,442,000	596,813,000
Total Investment	$1,775,254,000	$2,802,751,000
Annual Costs-Tidal Project		
Interest & Ammortization	$ 113,403,000	$ 179,040,000
Operation & Maintenance	2,545,000	3,596,000
Major Replacements	1,148,000	2,206,000
Pumping Power	102,000	102,000
Sub-Total Tidal Project	$ 117,198,000	$ 184,944,000
Total Investment-Transmission Lines		
Construction Cost of Transmission Lines	$ 48,500,000	$ 110,000,000
Interest During Construction	6,183,000	14,025,000
Total Investment	$ 54,683,000	$ 124,025,000
Annual Cost-Transmission		
Interest and Ammortization	$ 3,652,000	$ 8,283,000
Operation, Maintenance & Major Replacements	271,000	512,000
Sub-Total Transmission Lines	$ 3,923,000	$ 8,795,000
TOTAL-ANNUAL COSTS		
Passamaquoddy Tidal Project	$ 117,198,000	$ 184,944,000
Transmission	3,923,000	8,795,000
TOTAL	$ 121,121,000	$ 193,739,000

charges for the tidal project are based on the prevailing interest rate for water resources projects of 6-3/8% and a project life of 100 years. An average service life of 50 years was assumed for the transmission line which would also be financed at 6-3/8%. Although the line may be used by others to wheel power in the future, this has not been specifically identified, and no credit has been assigned to annual costs.

2. Discussion of Annual Costs

Major Annual Costs Considered - The following items are included in the annual costs for the project:

Amortization and Interest

Replacement of Major Equipment

Operation and Maintenance

Pumping Power (for reverse pumping)

Transmission Line Costs

The basis for annual Amortization and Interest costs are noted in the preceding paragraph.

The annual cost for replacement of major items of equipment is also shown in Table 7 in this section. The totals are $1,148,000 for the 500 MW project and $2,206,000 for the 1000 MW project.

These figures are based on the assumption that an equivalent of 25% of the following items must be replaced every 30 years during the life of the project:

Turbines, speed increasers, and governors

Generators and exciters

Filling and emptying gates

Lock gates

INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT

(ECONOMIC UPDATE - NOVEMBER 1976)

TABLE 6

ANNUAL OPERATION & MAINTENANCE COSTS

ITEM	Maintenance		Operation		Contract Services	TOTALS
	Labor	Material	Labor	Material		
DAMS	59,900	13,200	-	-	-	73,100
POWER PL'T NO. 1	542,100	135,700	756,600	85,100	11,400	1,510,900
FILL & EMPT. GATES	162,600	32,200	149,600	19,200	21,400	385,000
LOCKS	36,100	7,900	414,400	34,300	6,700	499,400
FISHWAYS	(Included in Powerhouse and Gates)					-
LUBEC CHANNEL	-	-	-	-	-	-
SERVICE FACIL.	64,000	12,800	-	-	-	76,800
PUMPING POWER	-	-	-	102,000	-	102,000
LANDS & DAMAGES & RELOCATIONS	-	-	-	-	-	-
TOT. 500 MW PROJ.	$864,700	$181,800	$1,320,600	$240,600	$39,500	$2,647,200
POWER PL'T. NO. 2	$524,000	$105,000	$533,600	$155,400	-	$1,318,000
TOT. 1000 MW PROJ.	$1,388,700	$286,800	$1,854,200	$396,000	$39,500	$3,965,200

INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT

(ECONOMIC UPDATE - NOVEMBER 1976)

SUMMARY OF ANNUAL COSTS*

	500 MW PROJECT	1,000 MW PROJECT
INVESTMENT (Thousands of Dollars)		
Tot. First Cost	$1,432,812,000	$2,205,938,000
Interest Dur. Constr.	342,442,000	596,813,000
Total Investment	$1,775,254,000	$2,802,751,000
ANNUAL COSTS (Thousands of Dollars)		
Interest & Amortization	$ 113,403,000	$ 179,040,000
Major Equip. Repl'm't.	1,148,000	2,206,000
Oper. & Maint.	2,545,000	3,596,000
Pumping Power	102,000	102,000
Total Annual Costs	$ 117,198,000	$ 189,944,000

* Does not include Transmission Lines from the project site to proposed connection points in the NEPOOL System.

TABLE 7

Interest at 6-3/8% and the sinking fund method of calculation was used.

After construction of the project is completed, various costs for operating, maintenance, services and supplies will occur. The separate O&M costs for the 500 and 1000 Megawatt projects are shown on Table 6.

Power Pumping is required to maintain higher operating heads in the high pool during neap tide periods. It is estimated that approximately 33,997,000 KWH of power will be required for the reverse pumping operation.

The estimated operation and maintenance costs for the transmission lines are based on the following data furnished by the Federal Power Commission:

Line Maintenance	$647/line mile
Capacity:	
500 MW	$0.34/kw
1000 MW	$0.31/kw

The annual operation and maintenance costs for the transmission lines are broken down as follows:

500 MW Project

156 miles x $647		$100,932
500,000 kw capacity x $0.34/kw		$170,000
	Total	$270,932
	Say	$271,000

1000 MW Project

312 miles x $647	$201,864
1,000,000 kw capacity x $0.31/kw	$310,000
Total	$511,864
Say	$512,000

3. Other Miscellaneous Annual Costs Considered

The following possible additional charges to the project were also considered, but were not included in the preceding analysis for the reasons noted:

Salvage Value

Self-Insurance

Loss of Land Taxes

Taxes Foregone

Net Loss to Fish and Wildlife

The salvage value of the tidal project would amount to the value of the land. For the project the land required is of small value. Other practices neglect salvage value on the basis that the entire investment should be recovered in the amortization period. On these bases, salvage has not been used in this study.

An annual allowance of 0.05 percent of the project first cost was made in the economic analysis in the 1959 Report as self-insurance against accidents. This allowance was not computed in the 1963/1964 reports and is therefore not included in this analysis.

With respect to loss of land taxes, it was assumed that the property obtained for the project would be obtained and held by a quasi-governmental agency which would not pay local taxes. Further, since previous studies showed that the residual values involved would be too small to influence the computation of costs, the values were not included in the computation of the benefit-cost ratio.

Regarding taxes foregone, if the tidal project is not built, the utility companies in New England and Canada would have to construct equivalent alternative facilities to meet the requirements of the growing power load. The companies in the U.S. would have to pay taxes on these facilities. On the other hand, the tidal project would be quasi-governmental and would pay no taxes which represent a loss in revenue to the people of the United States. Evaluation of United States water resources' projects customarily includes an item of taxes foregone in the annual economic cost of the project. However, this is not the case in Canada as electric power is supplied by Provincial organizations. It was concluded that because the tidal development is an international project, taxes foregone in Maine would not be included in the computation of the benefit-cost ratio and the cost of tidal power.

The implementation of the project would cause some loss to fish and wildlife through weir losses and reconstruction; and clam, lobster and sardine fishery losses. These losses are considered and accounted for under Section X E. entitled: Mariculture Benefits.

X. PROJECT BENEFITS

A. General

Construction of the tidal project would provide national, regional, State and local benefits of the following types:

1. Electric Power
2. Recreation
3. Area Redevelopment
4. Mariculture (fisheries)

Total annual benefits associated with the project would approximate $89,674,000 for the 500 MW project or $130,447,000 for the 1000 MW. Nearly 75 percent of the benefits would be credited to hydroelectric power generation, which would provide the revenues for repayment of all project costs. Table 8 presents a breakdown of annual benefits at June 1976 price levels for the four categories, and discussion on derivation of benefits is provided in subsequent sections.

TABLE 8

SUMMARY OF PROJECT ANNUAL BENEFITS
(June 1976 Price Level)

Category	500 MW	1,000 MW
Power	$64,286,000	$ 94,642,000
Area Redevelopment	19,513,000	29,930,000
Recreation	375,000	375,000
Mariculture	5,500,000	5,500,000
Total Annual Benefits	$89,674,000	$130,447,000

B. Power Benefits

As previously stated, electric power would account for the greatest part of project benefits and should provide the entire revenue for the project cost repayment, including interest over the project life. The power would be shared with Canada for consumption in the Eastern Maritime Provinces.

Output from the 500 MW project would be at a capacity factor of 44 percent; the capacity factor for the 1000 MW project would be approximate 27 percent. The Federal Power Commission, New York Regional Office indicates (attachments) the current type generation that would most likely be planned for this range in the load to be "combined-cycle" generation. An F.P.C. letter, dated 12 August 1976, (attachment 1) transmitted the following unit costs for combined cycle generation which are accordingly the unit benefit values (or cost of alternative) for the Passamaquoddy Tidal Power Project. The unit values shown in Table 9 are at June 1976 price levels and are provided for both ten percent (private financing for benefit-cost computation) and 6.375 percent (Federal financing for "economic efficiency test") interest rates.

TABLE 9

PASSAMAQUODDY TIDAL PROJECT
AT-MARKET UNIT POWER VALUES
(June 30, 1976)

Item	Unit	Unit Value	
		10.0%	6.375%
500 MW Project			
Capacity Value	$/KW/YR	45.00	25.50
Energy Value	mills/KWH	24.0	24.0

TABLE 9 (cont'd)

Item	Unit	Unit Value 10.0%	Unit Value 6.375%
1000 MW Project			
Capacity Value	$/KW/YR	45.00	25.50
Energy Value	mills/KWH	24.0	24.0

Table 10 below summarizes the total annual power benefits that would be credited to the 500 MW and 1000 MW. It is noted that transmission losses of eight percent for capacity and six percent for energy were assumed.

TABLE 10

ANNUAL PROJECT POWER BENEFITS*
(June 1976 Price Level)

(A) 500 MW Project

	6-3/8%	10%
500,000 KW x .92 x $25.50/KW	$11,730,000	$ -
x $45.00/KW	$ -	$20,700,000
1,932,000,000 KWH x .94 x $0.024/KWH	$43,586,000	$43,586,000
Total	$55,316,000	$64,286,000

(B) 1000 MW Project

	6-3/8%	10%
1,000,000 KW x .92 x $25.50/KW	$23,460,000	$ -
x $45.00/KW	$ -	$41,400,000
2,360,000,000 KWH x .94 x $.024/KWH	$53,242,000	$53,242,000
Total	$76,702,000	$94,642,000

*Includes Transmission Losses

C. Recreational Benefits

Recreation benefits would result from construction of the project.

Important future growth is expected in Maine's recreation industry, which is one of the states largest income producing activities. The Passamaquoddy Tidal Power Project, would be one of the few large scale tidal power plants in the world, and accordingly would attract a great number of visitors. The Bureau of Outdoor Recreation reported in 1963 that anyone who visited Acadia National Park, Moosehorn National Wildlife Refuge and other attractions in the region would also visit the tidal power project.

A plan recommended by the bureau included a tourist center tidal plant model, picnic areas, boat launching ramps and roadside overlooks, but did not include any cost estimates,

An analysis of trends in visitation, particularly sightseeing, at existing NED projects including the Cape Cod Canal and several reservoirs, indicates that visitation tends to increase every year, but at a declining rate. For example, at the Cape Cod Canal which is not a terminal attraction and which attracts mostly sightseers, visitation over the past 15 years has increased at an average rate of 3.7% annually, but the percentage increase during the early 1960's was greater than in the 1970's. This same kind of trend also holds true

ATTACHMENT NO. 5

the project benefits shall be considered to be increased by the value of the labor and other resources required for project construction and expected to be used in project operation, project maintenance, and additional area employment during the construction of the project. Otherwise, such labor and resources would not be utilized or underutilized.

Passamaquoddy lies in Washington County, which along with the adjacent counties of Penobscot and Hancock, was designated as a Title IV Redevelopment Area under PL 89-136 by the Economic Development Administration. In July 1976, the unemployment rate was 8.9 percent in Maine and 7.5 percent in Washington County. In Penobscot and Hancock Counties, the unemployment rates are 9.7 percent and 5.2 percent respectively - 17,600 people are currently unemployed.

The records of this office indicate that in the average civil works project, the labor cost approximates 27 percent of total construction costs. The construction cost including contingencies of the 1000 MW facility is currently estimated at $2,605,339,000; and the 500 MW facility at $1,621,543,000. Labor's share of the former amounts to $703,442,000; of the latter, labor's share is $437,817,000.

However, it is regular practice for a contractor to maintain a skilled skelton crew and fill the rest of his requirements from the local labor pool. It is estimated that 75 percent of the laborers will be locally hired for this project. While not all of this labor will come from the rolls of the unemployed, the jobs that they leave will be filled by either the unemployed, or the under-employed; thus 75 percent is used. For the 1000 MW facility, it is estimated that the work will take 8-1/2 years to complete. For the 500 MW facility, it is estimated that the work will take 7-1/2 years to complete.

With the interest rate at 6-3/8 percent, the derivation of the annual redevelopment benefits for both facilities is summarized as follows: (a) For the 1000 MW facility, total redevelopment benefits are estimated to be $29,930,000. Of this amount, $3,431,000 are annual benefits for labor engaged in maintenance and operation. (b) For the 500 MW facility, total redevelopment benefits are estimated to be $19,513,000. Of this amount, $2,380,000 are annual benefits for labor engaged in maintenance and operation.

Table No. 6 in the Operations and Maintenance Cost Section furnishes a breakdown of labor costs for major activities.

An analysis of the construction period was accomplished and the following table gives the estimated annual construction expenditures for local labor utilized for determining the area Redevelopment benefits from construction:

ESTIMATED REDEVELOPMENT BENEFITS

Year	500 MW Facility	1000 MW Facility
1st	$ 34,477,146	$ 37,966,000
2nd	74,210,531	99,702,475
3rd	75,196,095	107,656,180
4th	43,343,897	72,806,000
5th	40,060,269	68,585,300
6th	33,820,659	61,726,800
7th	18,717,446	44,844,300
8th	8,536,957	25,851,400
9th	-	8,441,550
	$328,363,000	$527,580,000

E. Mariculture Beneftis

The construction of the tidal power project could cause changes in Cobscook and Passamaquoddy Bays which would increase productivity of shellfish and other species of fishlife. In view of this, a brief analysis of the potential increase in fisheries by mariculture as practiced was made. It is noted that indepth studies should be made on fisheries if the tidal power project is studied further.

Current fisheries in Passamaquoddy Bay and Cobscook Bay differ markedly in their scope and value.

Passamaquoddy Bay (101 square miles) has active fisheries in herring, salmon, soft-shell clams and lobsters. The average landed value for 1973 to 1975 for each of these were as follows:

a.	Herring	-	$393,839	
			2,000	(one year only)
b.	Salmon	-		
c.	Soft-shell clams	-	90,331	(dramatic decline 1974 & 1975)
d.	Lobsters	-	103,430	
			$589,600	(Annually)

Incidental fisheries on alewives and winkles exist but their value is less than the one year for salmon.

Cobscook Bay (41 square miles) has active fisheries in lobster, clams, clamworms and groundfish such as shrimp and flounder. The most important fishery is for soft-shell clams. The total annual value of this fishery is approximately $1,400,000. The value of the lobster fishery is $250,000 and the value of the clamworm industry is $457,000.

Advances in mariculture can be expected primarily in development of strains of species that will grow faster under the site conditions available.

Another advance to be expected is the value of the product. It is becoming more and more evident that the ocean cannot supply all our needs for one reason or another. If we are to have the protein from this source, these extensive mariculture techniques will have to be applied.

A summary of Annual Losses and Gains in fisheries, if the tidal power project is constructed, based on 1975 dollars, is as follows:

In general, there will be an anticipated $2,000,000 fisheries loss for the entire project. This loss is accounted for in the estimated net gains for fisheries.

Gains from mariculture are more speculative, however, it is estimated that a total annual gain will not fall below $7,500,000.

The estimated minimum annual net gain or benefits derived from fisheries-mariculture is $5,500,000. As noted in Attachment 2 under Annual Gains for Mariculture, the development of mussels and snails (canned escargot) has excellent potential which could increase the annual gains well above the cited $7,500,000 for lobsters, oysters, salmon and trout.

Since the 500 and 1000 Megawatt projects impound the same bay areas, the estimated annual benefit from fisheries-mariculture is $5,500,000 for each project.

XI. PROJECT ECONOMICS

A. General

This section provides the results of two economic tests: the benefit to cost ratio and the economic efficiency test. The bases and significance of these tests is as follows:

The benefit-cost ratio results from a comparison of all project annual benefits (power, recreation, area redevelopment and mariculture) with total project annual costs, including transmission. In this analysis the annual cost of the project is partially a function of the prevailing Federal interest rate of 6-3/8 percent, while the assumed power alternative of "combined cycle" generation used for computation of project benefits is the most likely privately financed (10 percent, currently) alternative. The justification for authorization of all Corps of Engineers water resource projects is measured in terms of the benefit-cost ratio.

A comparison has also been made between project costs and benefits, including costs of alternative power sources (combined cycle) based on comparable financing, i.e. both the tidal project and its alternative are based on Federal financing (6-3/8 percent). This test is intended to assure that the Federally financed water resources development would be a more economically favorable addition to the power system than its privately financed alternative.

B. Benefit-Cost Ratio

Table 11 summarizes the benefit-cost ratio computation for the 500 MW and 1000 MW projects. Benefits and costs are as calculated in Sections X and IX of this report, respectively.

TABLE 11

PROJECT B/C RATIOS
(June 1976 Price Levels)
(Based on 10% Private Finance Rate)

Capacity	Annual Benefits ($)	Annual Costs ($)	B/C Ratio
500 MW	89,674,000	121,121,000	0.74
1000 MW	130,447,000	193,739,000	0.67

C. Economic Efficiency Test

Table 12 summarizes the economic efficiency test and resulting comparability ratios. It is noted that recreation, mariculture and area redevelopment benefits, which would be realized incidental to construction of the Passamaquoddy Project, would be foregone by the alternatives. Therefore, the values of the benefits are added to the alternative in order to obtain a reasonably valid comparison.

TABLE 12

ECONOMIC EFFICIENCY TEST
(June 1976 Price Levels)
(6-3/8% Federal Finance Rate)

	500 MW Facility	1000 MW Facility
Alternative Cost		
Electric Power	55,316,000	76,702,000
Recreation	375,000	375,000
Redevelopment	19,513,000	29,930,000
Mariculture	5,500,000	5,500,000
Total	80,704,000	112,507,000
Total Annual Cost For Passamaquoddy Project	121,121,000	193,739,000
Comparability Ratio	.67	.58

D. Discussion

It is readily apparent from the preceeding analyses that the tidal project would not afford any immediate relief to already burdened electricity customers of New England, construction costs of the International Project are prohibitively high and would result in initial-years production costs about double those of the private-sector "combined cycle" alternative.

The Passamaquoddy Tidal Project represents both intrigue and frustration to the hydraulic engineer. On one hand, an unlimited source of energy is available for development in an area of great reliance on foreign oil imports. Whereas, on the other hand, dams of over 300 feet in height must be constructed under adverse conditions to obtain relatively meager hydraulic heads for generation requiring inordinately large hydraulic macninery.

E. Marketing of Power

Based on the Project costs a preliminary estimate of what power from the project would be marketed for as compared to a combined cycle plant is shown in the following table.

TABLE 13

APPROXIMATE MARKETING RATE*

Size Project	Passamaquoddy Tidal Power	Private Alternative (Combined Cycle Plant)
500 MW	62.8 mills/KWH	34.7 mill/KWH
1000 MW	82.8 mills/KWH	41.5 mill/KWH

The distribution of the estimated marketed cost is further illustrated as follows:

*Includes Transmission Costs

TABLE 14

MARKETED COST DISTRIBUTION 500 MW (TIDAL)

	Annual Cost	Mills/KWH
Plant Interest & Amortization	$113,403,000	58.7
Plant Operation & Maintenance	2,545,000	1.3
Equipment Replacement	1,148,000	0.6
Pumping Power	102,000	0.1
Transmission Interest & Amortization	3,652,000	1.9
Transmission Operation & Maintenance	271,000	0.1
Administration	250,000	0.1
Fuel	000	0.0
Total	$121,371,000	62.8 Mill/KWH

F. Summary of Economic Analysis

A review of the project economics indicates that the International Passamaquoddy Tidal Power (500 MW or 1000 MW) project is not economically feasible under present conditions. Although the monetary benefits from power, area redevelopment, fisheries and recreation have increased, the construction costs and interest rates have also increased so that the latest Benefit-Cost Ratio for the project does not reach unity.

The "Summary of Project Economic Evaluation" results in a B/C Ratio of .74 to 1.00 for the 500 MW Plant and .67 to 1.00 for the

1000 MW Plant. This is based on a 100 year tidal power project life, 6-3/8% Federal interest rate and utilizing at-market values for capacity and energy.

The results of the "Economic Efficiency Test" also provides comparibility ratios of less than unity when the tidal power project is compared to the selected private alternative. The ratios resulting from this analysis are .67 to 1.00 for the 500 Megawatt plant and .58 to 1.00 for the 1000 Megawatt plant.

The "Repayment Rate" analysis indicates that electricity from the tidal power project would cost more than that generated by the selected private alternative.

From the various analysis, the 500 Megawatt facility is more feasible than the 1000 Megawatt plant. This is primarily due to the fact that the 500 MW plant produces 1,932 million kilowatt-hours of power whereas the 1000 MW plant would only produce 2,360 million kilowatt-hours of power. This increase in electrical production does not adequately compensate for the additional investment costs for a second 500 Megawatt plant. It is also noted that the benefits do not increase proportionally with the installed capacity size of the project.

Doubling the power output from 500 MW to 1,000 MW does not produce a corresponding doubling of energy production. In fact, energy production is increased by only 22%. Not only does energy production depend on the number of generating units in operation and the turbine head but also on the areas of the two pools.

In the case of doubling the capacity without altering the relative pool areas the rate of head loss is accelerated by the increased rate of filling of Cobscook Bay the low pool. This leads to reduced generating time resulting in a corresponding loss of energy production.

Exclusive of area redevelopment and power, it is opined that the benefits from fisheries-mariculture and recreation would not increase with the larger project.

XIII. MISCELLANEOUS

A. General

This section contains various items of information and data which relate to the project and are considered as matters of interest. During the course of this effort coordination was made with other groups and agencies who were accomplishing other project studies in the Passamaquoddy region.

B. Coordination with the Passamaquoddy Indian Tribal Tidal Power Project

During the early months of the Corps economic update study, the Passamaquoddy Indian Tribal Council, Pleasant Point, Maine proposed a small tidal power project and mariculture project in the vicinity of Bar Harbor in the northerly portion of Cobscook Bay. Their power plant and dam site would abut the northwesterly end of the Federally proposed Powerhouse No. 2. Their plant would produce about 5.2 Megawatts at a total estimated cost of $9,150,000.

The New England Division learned of this small project when the Tribal Council made a presentation on 17 February 1976 to the Federal Regional Council Energy Resource Development Task Force, of which the New England Division is a member.

The Tribal Council is currently seeking funds to further plan, design, construct and operate the project. If the larger Federal tidal power project is ever built, the operational procedures of the small plant would most likely have to be adjusted. In any event, it was recommended to the Council that they coordinate with the New England Division during their planning stages, with respect to water levels, elevations and inverts of structures, etc.

By letter dated 29 June 1976, this Division responded to queries from the Pleasant Point Tribal Council and noted various limitations, constraints and coordination which would be needed between the two projects. See Attachment No. 5 for location of the council tidal and mariculture projects.

C. Coordination with Proposed 250,000 Barrel Per Day Fuels Refinery and Deepwater Marine Terminal at Eastport, Maine

The Pittston Company is currently planning a fuel refinery facility in Eastport, Maine. The firm furnished a report dated 8 March 1976, titled: "An Environmental Assessment Report" prepared by Enviro-Sciences, Inc. for the refinery project and a "Draft Environmental Impact Statement" dated 13 October 1976.

The U.S. Environmental Protection Agency is responsible for the project's Environmental Impact Statement and since various Corps permits and approvals are required the assessment report was furnished to the Corps for review and comment. During the review, it was noted that the refinery would utilize some of the land formerly proposed in the tidal project which could affect construction, and rail/road access to proposed Powerhouse No. 1.

Representatives of the New England Division and the Pittston Company immediately conferred on the overall siting conflicts and prepared a revised layout sketch which makes the siting of the refinery compatible with Powerhouse No. 1 and associated facilities.

The refinery project EIS will contain the site sketch in addition to the following paragraphs:

<u>Other Federal Projects in the Area</u>

"Passamaquoddy Tidal Power Project. The Eastport area is a potential site for another major Federal Project: the proposed Passamaquoddy Tidal Power Project (the Quoddy Project). Conceived in the 1920's, the proposal was for an international energy production project involving the use of both Passamaquoddy and Cobscook Bays. Each bay was to be closed by a series of dams, with regulating gates and small craft navigation locks, to form a two-pool tidal project. Continuous power was to be generated by discharging water from the high pool in Passamaquoddy Bay to the low pool in Cobscook Bay through turbines located between the two pools. However, in the early 1930's, Canada withdrew from the project and work was suspended.

MODIFIED LAYOUTS OF
PITTSTON REFINERY AND PASSAMAQUODDY TIDAL POWER

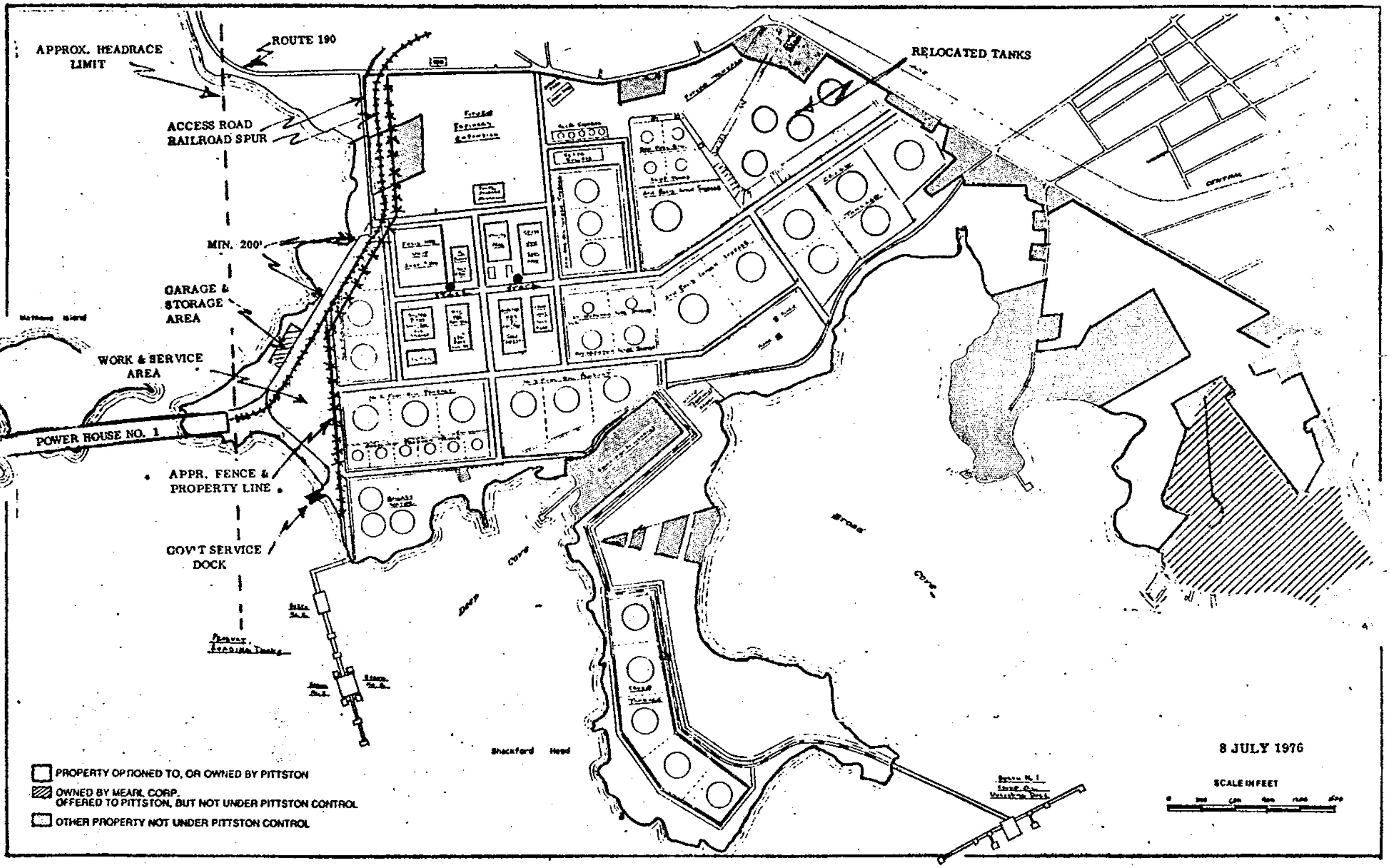


PLATE NO. 8

In 1935 the Government of the United States undertook development of a single-pool project using only the waters of Cobscook Bay on the United States side of the international boundary. This work was suspended in 1936 when no further funds were made available for the project.

As the result of continued interest in the Passamaquoddy tidal power project on the part of the people of Maine and New Brunswick, supported by an increasing awareness of the need to exploit all possible sources of energy, the International Joint Commission was requested by both governments to study a large-scale international tidal power project in Passamaquoddy and Cobscook Bays.

In 1964, recommendations were submitted to the Secretary of the Interior for authorization of a combination of the Quoddy Project and the proposed Dickey-Lincoln School Lakes Project involving the construction of a hydroelectric dam on the Upper Saint John River. These projects have now been separated. The Dickey-Lincoln School Project is in the preliminary design state, and the Quoddy Project has been suspended indefinitely while the Corps of Engineers is re-evaluating and updating the costs of the project.

The preliminary site plans for both the proposed refinery and deep-water marine terminal at Eastport and the Passamaquoddy Tidal Power Project have been coordinated between the Pittston Company and the Corps of Engineers, New England Division. As shown on the preliminary sketch, Plate 8 herein, the layout of the two projects appears compatible.

The Pittston Company has been advised that in the event the tidal power project is authorized and constructed, there would be operational and waterborne navigational constraints on shipment of their crude and finished projects. This is principally due to the dam system and navigational lock proposed in Head Harbor Passage. The water transport route to and from the refinery, as well as the associated docking facilities, will be in the "low pool" of the tidal project in which the water level normally operates between mean sea level and mean low water elevations. The lock would be one of the largest in existence and be a considerable engineering and construction accomplishment.

The basic tidal power project includes the construction of a 415' x 60' x 21' deep navigational lock in Head Harbor Passage. The preliminary estimated Total Investment Cost for this lock is $22,140,000 for which present planning is that the Government will provide all construction and operation and maintenance costs.

In view of possible future navigational needs, two alternate larger size locks were considered for the project; namely 830' x 120' x 42' deep and 1,250' x 180' x 67' deep; their preliminary estimated Total Investment Costs are $86,443,000 and $140,167,000, respectively. The lock size will be a matter for future determination, and based on costs versus navigational needs and benefits if and when the tidal project is authorized."

D. Real Estate/Engineering Reconnaissance and Lands and Damages

The updated estimated cost for Lands and Damages is $4,074,000 including contingencies and acquisition costs. The estimate is based on the benefit of a preliminary field investigation of the project area within the United States during 12-15 July 1975 by NED Real Estate and Engineering personnel. The portion of the project in Canada was not physically inspected for this report and the estimated lands and damages in Canada have been increased by using a projection factor.

E. Construction Cost Index Comparisons

The updated project cost estimates are based on the applicable wages, materials, etc. costs as prevailed on or about 30 June 1976. For 1 July 1976, the Engineering News Record reported a Construction Cost Index of 2413. It is interesting to note that escalation of costs has increased the index as follows in relation to various reports prepared on the tidal project:

TABLE 15
CONSTRUCTION COST INDEX COMPARISONS

Item	ENR Index
1913 - Base Year for Index	100
1935-1936 - Construction Estimate	206
October 1959 Report	759
April 1961 Report	838
July 1963 Report	909
August 1964 Report	948
July 1965 Report	977
July 1973 Cost Update	1901
July 1974 Cost Update	2040
July 1976 Cost Update	2413

F. Fuel Prices during Study Period

During the early phases of this study, the Federal Energy Administration noted that the approximate cost of fuel was:

TABLE 16
FUEL COSTS DURING STUDY PERIOD

Fuel	Cost
CRUDE OIL	
Imported (delivered to U.S.)	$13.27/BBL
Domestic	$ 9.12/BBL
Weighted	$10.76/BBL
COAL	
Bituminous (Transportation not Included)	
Contracted	$16.90/Short Ton
Spot Purchases	$22.40/Short Ton
-	$ 1.24/Million BTU
GAS	
Natural	$ 1.661/Million BTU
DISTILLATE FUEL OIL	
#2 Retail	$ .4227/Gal
#2 Wholesale	$ .3240/Gal
RESIDUAL FUEL OIL	$ 1.825/Million BTU

NOTE: Light oils (#2, Kerosene etc.) are considered in the Combined Cycle alternative

G. Buy American Act (1966 October)

During the course of the study the question arose if turbines and generators, etc. which are manufactured in foreign countries could be utilized in the project.

It appeared that monetary savings in the vicinity of 20-30 percent could possibly be realized from the purchase of foreign equipment. However, in the late stages of the study the consultant received information which indicated that foreign equipment costs were about the same as American equipment costs. Further questions surfaced as to the ability of foreign manufacturers to meet equipment delivery dates and furnishment of replacement parts, etc.

In part, the act states in general that American made products have to be purchased and utilized unless the head of the Department determines it to be inconsistent with the public interests or the cost is unreasonable.

In view of the intent of the Act and all aspects it was determined to be in the best interests to "Buy American" and to have the cost estimates herein based on that premise.

H. Conservation of Natural Resources

A power plant, such as the tidal project which requires no fuel, would conserve existing supplies of fossil fuels. The tidal project would conserve approximately 2,700,000 barrels of oil, 1,000,000 tons of coal, or 16.5 billion cubic feet of natural gas each year.

In respect to conservation of natural resources, it has been noted that the annual energy produced by the 500 Megawatt tidal power plant is equivalent to approximately 2,700,000 barrels of fuel oil.

Aside from the savings in the natural resource itself and according to these figures, the tidal power plant could save costs involved with pumping, transportation and manufacturing of oil in the amount of approximately $43,470,000 annually (2,700,000 Bbls x $16.00/Bbl).

XIII. ITEMS REQUIRING FURTHER STUDY

Items requiring further study in connection with the tidal power project are:

a. A broad investigation of construction methods on structures in the sea.

b. Investigations into financial aspects that can be improved by the use of lower interest rates when applied to the use and conservation of natural resources.

c. A position from which to meet the situation when alternative fueled plants are no longer competitive because of fuel shortages or costs.

d. Continual investigation into sizes and types of generators and turbines which could reduce construction costs.

e. Investigation of reuse of surplus excavated rock and materials which could bring some monetary revenue, thereby reducing initial project costs.

f. Further consideration should be given to the economic-socio impacts and benefits of Passamaquoddy associated with recreation, economic development and quality of life in the region.

g. Accomplishment of indepth environmental studies to determine the various impacts caused by the project, and the investigations which consider the impact of natural resource development on the overall economic improvement in the New England region.

h. Initiation and development of coordination and participation programs with Canadian officials and counterparts for a joint project.

i. Initiation of an Open Planning/Public Participation Program so as to incorporate the views of interested individuals, groups and public officials.

j. This economic feasibility study did not investigate the establishment or costs of living and support facilities for employees working on the project. It was considered best to defer this investigation until it was known if further study on the project is warranted. At that time an analysis would be made of the region to determine whether or not the private regional facilities (ie: housing, commisary, etc.) are sufficient to care for project employees. If not, provisions for these support facilities would have to be considered.

k. Excavation for the two powerhouses and water raceways will produce about 66,000,000 cubic yards of surplus impervious earthfill and rock which will have to be disposed. Acceptable disposal locations for this material will have to be determined at a later date as part of environmental impacts, etc. For this estimate a disposal area opposite the powerhouses in the deep portion of Western Passage is being utilized. This location was used in the 1959 and 1964 reports. Informal discussions with Canadian fisheries personnel indicated that this site was all right for the present but that further environmental studies would be necessary later on.

l. Additional Real Estate Reconnaissance to inspect lands and damages in Canada is considered a necessity.

m. It is anticipated that water temperatures in Cobscook and Passamaquoddy Bays will rise after the tidal project is constructed. In view of this, the potential of mariculture development in the bays should be fully investigated.

n. It is possible that detailed studies would show some economy in precasting and floating into position filling and emptying gate structures. The need for cofferdams would be eliminated or reduced; and, thereby, it is possible that the overall cost would be reduced. Further detailed studies to develop this idea should be conducted in the future.

o. Investigation of fiscal requirement, user determinations, economic evaluation, etc. of a larger size navigational lock in the event the proposed oil refinery and the tidal projects are both built.

p. On 10 November 1976 a meeting was held with representatives of New England Power Planning (NEPLAN) which is the power planning group for the New England Power Pool companies (NEPOOL), to inquire how they view the Passamaquoddy project integrating with the overall power requirements in New England. The NEPLAN personnel stated that if the Quoddy project materializes they see a need for a plant which can provide continuous power for about 14 hours per day for a five (5) day week rather than a peaking type plant. They were assuming that the tidal power project might be going on line in the early -mid 1990 timeframe. In view of this comment, it is recommended that a study be made to review future New England power needs and redetermination of the mode of operation for the project. This effort should be accomplished in coordination with the Federal Power Commission, NEPOOL, and other interested power groups.

q. Investigation and preparation of project economics based on "life-cycle" costing methods is necessary. In order to respond to a request by the Honorable James B. Longley, Governor of Maine, a "life-cycle" study will be made and presented in a Supplemental Report.

r. An updated economic analysis of various All-American tidal power plans in Cobscook Bay is required and will be included in a Supplement to this report.

s. Another study into required facilities and associated costs for providing recreational support facilities in the project area must be accomplished.

XIV. SUMMARY, FINDINGS AND RECOMMENDATIONS

A. DISCUSSION AND FINDINGS

1. This feasibility report reflects a review and update of costs and benefits of the International Passamaquoddy Tidal Power Project as proposed in "Supplement to July 1963 Report, the TIDAL POWER PROJECT and UPPER SAINT JOHN RIVER Hydroelectric Power Development report dated August 1964 and prepared by the Passamaquoddy-Saint John River Study Committee. Its purpose was to determine if the tidal power project is economically feasible under present day conditions and price levels and if further investigations and studies are warranted.

2. The total investment cost for the 500 megawatt (MW) and 1000 megawatt size tidal power projects are $1,775,254,000 and $2,802,751,000 respectively and are based on price levels prevailing on 30 June 1976.

3. During the course of the study, it was determined that although power is the principal purpose and benefit producer for the project, other benefits which could be derived are area redevelopment, fisheries (mariculture) and recreation.

4. The annual costs for the project involve amortization, interest, operation, maintenance, and periodic replacement of major items of equipment.

5. The summation of the pertinent economic figures for the project based on a 100-year life and at 6-3/8% Federal financing are as follows:

Size Project	Total* Investment Cost	Annual Costs	Annual Benefits	Benefit-Cost Ratio
500 MW	$1,775,254,000	$121,121,000	$ 89,674,000	0.74
1000 MW	$2,802,751,000	$193,739,000	$130,447,000	0.67

*Includes tidal power project and transmission.

6. Utilizing the Total Investment Cost values, the estimated cost of installed power based on a per kilowatt basis is approximately $3,660/kw for the 500,000 kilowatt project and $2,927/kw for the 1,000,000 kilowatt project. These per kilowatt costs are further broken down against the total investment costs of various project components as follows:

Component	Total Investment Cost	Cost/kw
TIDAL POWER PROJECT		
500,000 kw Plant		
Dams	$ 270,441,279	$ 541
Filling/Emptying Gates	447,360,014	895
Powerhouse No. 1	948,374,630	1,897
Navigation Locks	70,854,535	142
Miscellaneous	38,223,542	76
	$1,775,254,000	$3,551
Transmission	54,683,000	109
	$1,829,937,000	$3,660
1,000,000 kw Plant		
Dams	$ 274,227,041	$ 274
Filling/Emptying Gates	453,622,367	454
Powerhouse No. 1 & 2	1,937,035,134	1,937
Navigation Locks	71,846,390	72
Miscellaneous	66,020,068	66
	$2,802,751,000	$2,803
Transmission	124,025,000	124
	$2,926,776,000	$2,927

7. Even if the dams, filling gates, etc., did not have to be built, the construction cost on a per kilowatt measure for the initial 500 MW powerhouse alone is about \$1,897/kw which is high in comparison with other power projects. The total investment costs for furnishing and installing 40-12,500 kilowatt turbines and generating equipment is \$441,121,000 and the cost of the remainder of the powerhouse is about \$507,254,000. This breaks down into \$882/kw for equipment and \$1,015/kw for civil structure to house the units.

8. The high unit price for the powerhouse is due to the low head (average of 11') of the tidal hydro project. The low head necessitates larger diameter (320") sized turbines which in turn requires a larger civil structure for equipment containment and operation. The turbines would be the largest ever built. In general, the cost of turbine equipment increases approximately in relation to the equipment radius squared (r^2).

9. The tidal phenomenon offers the project a predictable year-round flow of water to maintain the anticipated levels of power output. The facility is not dependent on rainfall or subject to lengthy drought periods which affect power production in some normal run of the river type hydropower plants.

10. Considerations which are noteworthy and possess merit are that natural energy resources would be conserved, and by the nature of the tidal power project, the following objectives of the New England Federal Regional Council's objectives would be met:

a. Reduce the region's high dependence on petroleum and its attendant high costs.

b. Reduce the region's adverse weighted average energy cost differential versus the balance of the United States.

c. Improve both New England's energy posture and industrial investment climate.

11. Although the project purpose is power, the Benefits-Cost ratio based on power alone is only 0.53 to 1.00 for the 500 MW facility and is 0.49 to 1.00 for the 1000 MW facility. Power makes up about 72% of the benefits derived from either size project.

12. The project benefit/cost analysis is based on price levels of 30 June 1976 and was prepared in accordance with current Corps of Engineers procedures created by Congress in the Flood Control Act of 22 June 1936. During the course of the study, comments from private and state offices indicated that the project should be analyzed on a life-cycle cost basis. Briefly, this relatively new phrase "life-cycle costing" is the evaluation of alternative systems, a comparison of their total annual owning, operation and maintenance over the economic life of the facility. This costing method projects and accounts for future escalation costs of fuel, operation and maintenance, etc. in the analysis and is not limited to utilizing costs prevailing during the present period. To honor a recent letter request from Governor James B. Longley of the State of Maine, this Division is preparing a life-cycle costing analysis of the tidal power project and anticipates its completion about 1 March 1976. The analysis by this method is for information purposes only.

13. Based upon the below unity Benefit-Cost ratio for the international concept for tidal power, it does not appear at this time that further study for a 500 megawatt facility expandable to a 1000 megawatt facility is warranted; nor that a Plan of Study should be initiated to provide additional engineering and environmental studies for the international project as such.

14. During the course of the economic updating effort, noticeable interest was expressed by various sectors in the tidal power project that was partially constructed in 1935-1936. The original project only required about 1-1/2 miles of dams and was completely in Cobscook Bay and within the United States. As a result of this interest, the New England Division considers it advisable to investigate and reanalyze the project costs and benefits which could be derived from the original smaller project. Further investigation into the original project with some modifications would be beneficial and of value for future decision making.

15. That in lieu of terminating further study of tidal power in the Cobscook and Passamaquoddy Bay region at this time (due to the low Benefit-Cost ratio of the present international tidal power concept) the option for this Division to study other possible tidal power alternatives in Cobscook Bay and entirely within the United States be conducted. The studies are to be commenced and conducted in Fiscal Year 1977 with an anticipated completion date of 1 April 1977.

16. That interested public and private sectors, proper Canadian authorities and the International Joint Commission be advised of the results of this economic feasibility study as soon as possible for their information and future planning purposes.

B. <u>RECOMMENDATIONS (For First Phase of Study Only)</u>:

(NOTE: See final Recommendations in Supplement dated 29 April 1977).

For this first phase of study, the Reporting Office recommends that:

a. Under the present conventional Benefit-Cost-Ratio (BCR) method of evaluation as dictated by Congress for water resource projects, further study of the International Passamaquoddy Tidal Power Projects is not warranted and should be discontinued.

b. This Division continue its investigation and reporting on other possible tidal power projects in Cobscook Bay which would be entirely within the boundaries of the United States.

c. This Division honor the request of Honorable James B. Longley, Governor of Maine, and conduct a "life-cycle" costing analysis of the 500 Megawatt International Passamaquoddy Tidal Power Project for his information and use.

d. Final decision to terminate or continue further study on a tidal power project in the region be deferred until the results of the overall study on a tidal power currently being accomplished by the U.S. Energy Research and Development Administration are known and analyzed, as well as when the additional work on All-American Plan alternatives and life-cycle analysis is completed by this Division in April 1977. Also, if an alternative tidal power project is found to be economically feasible, that this Division be authorized to initiate a Plan of Study and prepare a Survey Scope type study for the project.

e. This document be considered an interim Economic Feasibility Report pending completion of other ongoing studies and our reanalysis of other tidal power alternatives in April 1977.

ATTACHMENTS

FEDERAL POWER COMMISSION
REGIONAL OFFICE
26 Federal Plaza
New York, New York 10007

August 12, 1976

Mr. John Leslie
Chief, Engineering Division
Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

As requested in your letter of April 19, 1976, we have made a market study and determined at-market and at-site power values for the proposed Passamaquoddy Tidal Project (Quoddy). Since the International Passamaquoddy Engineering Board report in October, 1959, New England's electric utilities have established the New England Power Pool (NEPOOL) and also NEPEX and NEPLAN, NEPOOL operating and planning arms, respectively. The Interconnected New England System is one of four areas comprising the Northeast Power Coordinating Council (NPCC), one of nine Regional Reliability Councils in North America. The New York State Interconnected System, New Brunswick Electric Power Commission, and Ontario Hydro are the other three NPCC entities. In light of these developments and single system approach to bulk power supply planning and operation in the region, the Interconnected New England System was selected as the market for Quoddy power. Also, although international in character, for study purposes, as agreed upon with your staff, Quoddy output was assumed to be utilized solely in the United States. Accordingly, required transmission for the various project installations considered and their economic evaluation were based on the concept of a U.S. market only.

New England is a winter peaking region. The 1975 peak demand of 13.5 million kilowatts occurred on December 19. This is estimated to increase to 23.8 million in Winter 85-86 and to 41.0 million in Winter 95-96. Installed capability in New England totalled 20.0 million kilowatts at the close of 1975 and is scheduled to expand to 28.4 million by the end of 1985 and to 51.0 million in 1995. The following table shows the composition by prime mover type of the 1975 (actual) and 1985 (scheduled) capabilities as reported by the utilities on April 1, 1976 in response to FPC Order 383-3:

ATTACHMENT NO. 1

New England

Installed Generating Capability
(Megawatts)

Fossil Steam	11914	13062
Nuclear Steam	3364	10071
IC/GT	1732	1852
Combined Cycle	90	475
Convent. Hydro	1308	1300
Pumped Storage	1632	1632
Total	20040	28392

Of an additional 22.7 million kilowatts currently planned for the decade after 1985, some 15 million are expected to be nuclear.

Our analysis was based on the description of the project in the Passamaquoddy-St. John River Study Committee's August 1964 Supplement to the July 1963 Report of The International Passamaquoddy Tidal Power Project and Upper Saint John River Hydroelectric Power Development. The supplement outlines installation of an initial 500 MW and an ultimate 1000 MW of firm, two hour duration, peaking power. It assumes operation of a two-pool plan with supplemental pumping during the neap tides and stipulates that the use of reversible pump-turbines to increase the head during neap tides will assure the availability of the full installed capacity during all required peaking periods. Detailed information regarding the capacity during off-peak energy production was not available, but peak and off-peak energy production data shown in the report for a three-month period indicated operation of the project at a capacity factor of about 27.5 percent. Annual operations were assumed to conform to the operating mode depicted for this three-month period.

Examination of long range NEPOOL generation expansion plans and system load duration curves showed that the New England load could accommodate Quoddy peaking capacity in the 1990-2000 period. Analysis of historical daily load curves indicated that Quoddy could be "peaked" over a two-hour period on a daily basis. There are, however, some reservations regarding the ability to predict future load shapes with any assurance. The current emphasis in the nation regarding energy conservation and the evolving interest in utility load management raise the possibility that future New England load characteristics may not retain the sharp, short duration load "spikes" experienced in the past. Prior studies by the FPC staff indicated that with some additional pumping, the tidal project could possibly be operated at 500 MW to serve daily peak loads for up to four hours.

In consideration of the assumed characteristics of the project, combined cycle capacity operating at 30 percent capacity factor was selected as the most appropriate alternative. Capital costs were estimated at $250/kW at June 30, 1976 price levels, heat rate at 9000 Btu/kWh, and fuel costs at $2.50/million Btu's. Annual capacity and variable energy costs of power from the combined cycle alternative delivered to the NEPOOL transmission network, plus any required adjustments, yield at-market power values.

Project transmission requirements were based on consideration of projected power flows on the NEPOOL system and the proposed development at Quoddy and an assumption that Dickey-Lincoln and associated transmission would be in service. For the initial 500 MW installation, two 345 kV outlets were assumed - one to the existing Orrington 345 kV switching station near Bangor, and another to the existing Maine Yankee 345 kV switchyard at Wiscasset. The estimated cost of transmission for this scheme was about 48.5 million dollars.

For the 1000 MW installation, the Quoddy-Maine Yankee 345 kV circuit was looped through an expanded Orrington switching station, and a 345 kW line was added from Orrington to a new substation in the Livermore Falls, Maine area, thence to an assumed Beebee, New Hampshire termination of the Dickey-Lincoln transmission, and to the existing Scobie 345 kV substation near Manchester, New Hampshire. Total cost of required transmission for the 1000 MW proposal was estimated at about 110 million dollars.

Based on the foregoing, at-market and at-site power values as of June 30, 1976 for the proposed Passamaquoddy Tidal Project at ten percent of money (private financing) and 6.375 percent (federal financing) are estimated as follows:

Passamaquoddy Tidal Project
At-Market and At-Site Power Values
(June 30, 1976)

private financed rate
Federal Finance Rate

Cost of Money	%	At-Market 10.0	At-Market 6.375	At-Site 10.0	At-Site 6.375
500 MW Project					
Capacity Value	$/kW/YR	45.00	25.50	28.00	15.50
Energy Value	mills/kWh	24.0	24.0	23.0	23.0
1000 MW Project					
Capacity Value	$/kW/YR	45.00	25.50	25.50	14.00
Energy Value	mills/kWh	24.0	24.0	23.0	23.0

The at-market capacity values reflect a credit applied to the delivered cost of power from the alternative. No adjustment was made to the cost of energy. At-site values reflect the effect of project transmission costs, including losses, on the at-market values.

Pumping energy requirements associated with Quoddy would come from nuclear generating stations in New England. Nuclear capacity is currently projected to be in the order of 25 million kilowatts by 1995. This should be more than sufficient to cover estimated base load requirements and pumping energy needs of pumped storage capacity in service in the time frame assumed for completion of the project. Based on current operating costs, pumping energy costs from nuclear sources are estimated at about 3.0 mills/kWh.

If we can be of further assistance to you in your studies, do not hesitate to contact us.

Sincerely,

James D. Hebson

James D. Hebson
Acting Regional Engineer

ATTACHMENT NO. 2

POTENTIAL OF MARICULTURE IN THE PASSAMAQUODDY BAY AND COBSCOOK BAY REGION

Introduction

The United States has indicated an interest in reviewing the current status of the Proposed Passamaquoddy Tidal Power Project. To this intent, the U.S. Army Corps of Engineers has been directed to update the economics and technology of the original proposal. The final outcome of this analysis is a first cut "Benefit-Cost Ratio." This report will discuss one particular aspect of the overall analysis; the potential of mariculture as a benefit to be derived from project implementation.

Out of necessity, the report will be superficial in its depth of analysis. A major reason for this lies in the realm of prediction. We are dealing with a relatively new field of endeavor but one which is gaining continuously in importance. The problem of predicting a dollar value in 1975 for 1995 is of particular concern and lends itself to qualitative rather than quantititive analyses.

Methodology

The introduction points the way to the problem of assessing the potential for mariculture. Hopefully, the methodology will lead to a useful conclusion. The problem will be addressed in five stages. The first stage will be to identify those species which will lend themselves to mariculture in the proposed environment (Passamaquoddy Tidal Power Project). The second stage will be to assess the "profitability " of those species. The third stage will be to assess the expected advances in mariculture technology and the effect those advances may have on the successful culturing and resultant profit during the middle 1990's. The fourth stage will be to assess the current fisheries and their value to the region both now and in the future. The fifth stage is a summary of expected losses and expected gains.

Where factual and quantitative data is available, it will be incorporated into the assessment. Where hard data is lacking, a best estimate will be utilized and so indicated.

There are several pilot adventures into mariculture as well as Federally sponsored programs investigating techniques and feasibility of this newest form of food production. Federal, State and private firms will be queried for their knowledge. No attempt will be made at generating new data at this time.

Potential Species

There are several species which lend themselves to mariculture in one form or another. The species which have the most promise for this project are Atlantic salmon, trout, lobster, oysters, mussels and snails. These species all exist in the region and have been involved in a pilot or experimental mode for some time. The exception to this is the snail. Attempts at mariculture on this animal are not known.

There is a potential for intensified sport fishing in the form of introducing an exotic species, such as Coho or Chinook Salmon.

Estimated Success

There is very little data pertaining to the "profitability" of the chosen species. However, pilot studies indicate that the following species can be reared and indications are that they will be profitable.

1. Atlantic Salmon - This species could be "sea-ranched" providing strains can be developed which would require less forage area than currently required. Estimates of success for this endeavor show a gross of $1,000,000 annual at 500,000 pounds. 1976 prices would be $2.00 per pound.

2. Trout - These species could be reared in holding pens or cages. Brook trout and rainbow trout lend themselves well to this method. The activity will center about a summer grow-out and has two limiting factors; the source of small fish for rearing and the number of suitable sites within the bays. Total production is not known at this time but it is not inconceivable that it could far exceed the sea-ranching of Atlantic Salmon in poundage. Prevailing value per pound is $2.00. For purposes of this analysis, an annual production of 500,000 pounds will be used. No estimate of cost of operation has been made nor has any figure been derived for initial cost of cages and fingerlings.

The production of fingerlings requires warm water and a hatchery. Solar panels with heat exchangers can produce the warm water. This portion of the process could very well be a business in its own right. A centralized hatchery operation could supply the grow-out phase investors with their supply of fingerlings.

3. Lobster - There are conflicting points of view as to the time and success of rearing lobster. The project will create an embayment which may or may not provide a habitat for semiwild rearing of lobsters. More than likely, the effect of reducing tidal amplitude and warming the water during the summer will make highly sophisticated and technical plant rearing more attractive to this region. Therefore, as a result of project implementation, the way would be made easier to develop a series of rearing plants. There may be different phases of this industry developed. It is not difficult to see separate businesses and their satellites such as seed stock production, feedlot conversion, complete grow-out and scampi production. Total production per plant in the complete grow-out stage would be at least 500,000 pounds. Current wholesale prices average $1.85 and range from $1.50 to $2.25. This equates to an annual gross of $750,000 to $1,125,000. Scampi operations could be expected to repeat this in terms of pounds produced.

4. Oyster - This species has been cultured in pilot plant and small commercial establishments and annual gross values range from $100,000 to $200,000 per million oysters reared and sold. One venture reports a profit potential ranging from $30,000 to $103,000 per million sold in 1975. This was after an annual operation cost of $77,000 and an initial investment of $85,000.

Production would depend upon suitable sites for rearing and increased market demand. It is not inconceivable to expect an annual gross of $500,000. This value could dramatically increase as the demand for oysters is developed.

5. <u>Mussel</u> - Of all the species listed, this one is the easiest to culture. As yet in North America, this species does not have wide acceptance. There have been many attempts at developing local markets. For various reasons, not due to the mussel, they did not succeed. There are no known values which can be assigned to this species but it definitely warrants an intensive investigation. I feel that this may be one of the better ventures in mariculture which will show a high benefit. Best estimate is a 2-3 million dollar annual gross.

6. <u>Snails</u> - A recent development in the fisheries of that area has provided a new potential for maricuture. The local whelk has been the target for a new industry. It is captured and prepared for market as canned escargot. This species is reported to have a high sales demand and value. Ventures into rearing this species could be varied but a grow-out form may be best. It would best work out as a satellite or ancellary business to fish production, utilizing the remains of the prepared trout or salmon for food. The benefit to be taken for this species is not known, however, it has potential and should be seriously investigated.

<u>Advances Expected by 1990's</u>

Primarily advances in mariculture can be expected in development of strains of species which will grow faster under the conditions available, nutrition and marketing of products. Sources of warm water will be more sophisticated than they are now.

Another advance to be expected is the value of the product, It is becoming more and more evident that the ocean cannot supply all our needs for one reason or another. If we are to have the protein from this source, then intensive maricultural techniques will have to be applied.

Current Fisheries

Current fisheries in Passamaquoddy Bay and Cobscook Bay differ markedly in their scope and value.

1. Passamaquoddy Bay has active fisheries in herring, salmon, soft-shell clams and lobsters. The average landed value for 1973 to 1975 for each of these were as follows:

a.	Herring	-	\$393,839
b.	Salmon	-	\$ 2,000 (one year only)
c.	Soft-shell clams	-	\$ 90,333
d.	Lobsters	-	\$103,430

2. Cobscook Bay has active fisheries in lobster, clams, clamworms and groundfish such as shrimp and flounder. The most important fishery is for soft-shell clams. The value of this fishery is approximately \$1,400,000. The value of the lobster fishery is \$250,000 and the value of the bait worm industry is \$457,000.

Summary of Losses and Gains

Values, their sources and assumptions are tabulated later in the report. In general, there will be an anticipated \$2,000,000 loss for the entire project. This is divided into a \$323,800 loss for Canada and a \$1,666,000 loss for the U.S. The loss for the U.S. is somewhat inflated due to the nature of a worst case assumption on major fisheries.

Gains from mariculture are more speculative but estimates indicate a total annual gain will not fall below $7,500,000.

Annual Losses - Canada

Weir Losses and Reconstruction (1)	$129,000
Lobster Pound Losses (1)	450,000
Clam Processing Losses (1)	100,000
Fixed Loss Total	$679,000x3.18 (3) =$2,159,000
Annual Loss at 6% (2)	$129,000
Weir Maintenance (1) (Annual) $8,000 x 3.18 (3)	$ 25,500
Clam Fishery Loss (4) (Annual)	90,300
Sardine Fishery (5) (Annual)	79,000
Total Annual Losses	$323,800

(1) These values are taken from Report of the Fisheries Board in the Investigation of the International Passamaquoddy Tidal Power Project 1961.

(2) Passamaquoddy Report 1958.

(3) Inflation rate supplied by J. Callahan to convert 1958 dollar value to 1975 dollar value.

(4) A worst case loss for the clam fishery was assumed. The report (see above) indicates a ten-year loss is expected. This assumption considers a permanent loss.

(5) This value is based upon a 20% reduction in existing fisheries value. It includes a $15,000 loss for scales.

1973	$154,000	(36,991 + 332,342) x .2 =	$ 73,866
1974	58,000	(61,562 + 369,725) x .2 =	86,257
1975	59,000	(65,704 + 315,158) x .2 =	74,172

$271,00 ÷ 3 = $90,333 $234,295 ÷ 3 = $78,100

Total = $90,333 + 78,100 = $176,400 x 8,000 x 3.18 =$200,000

There are no estimates for lost groundfish value but they would not exceed $10,000.

It is not anticipated that the lobster fishery will decline measurably.

Annual Losses - United States

Weir Loss and Reconstruction(1)	$2,000 x 3.18 =	$ 6,400
Groundfish Loss(2)		10,000
Lobster Loss(2)		250,000
Clam Loss(2)		1,400,000
Total Annual Loss		$1,666,000

(1) This value was taken from Report of the Fisheries Board in the Investigation of the International Passamaquoddy Tidal Power Project, 1961.

(2) A worst case loss for these fisheries was assumed. The values for the fisheries were obtained from Maine Department of Marine Resources fisheries statistics.

(3) There is a viable bait worm fishery which will be adversely affected by this project. Assuming that 60% of the landed figures come from Cobscook Bay, the annual value of the fishery is $457,000, this brings a worst case loss in Cobscook Bay to over $2,000,000.

Annual Gains for Mariculture

Canada - Passamaquoddy Bay

Salmon	-	1 venture	$1,000,000
Trout	-	2 ventures	1,000,000
Oysters	-	5 ventures	500,000
Lobsters	-	2 ventures	1,000,000
Mussels	-	excellent potential	(1,000,000)
Snails	-	excellent potential	*
			$3,500,000 ($4,500,000)

United States - mainly Cobscook Bay

Salmon	-	1 venture	$ 500,000
Trout	-	4 ventures	2,000,000
Oysters	-	5 ventures	500,000
Lobsters	-	2 ventures	1,000,000
Mussels	-	excellent potential	(2,000,000-3,000,000)
Snails	-	excellent potential	*
			$4,000,000 (6-7,000,000)
Total Annual Gains			$7,500,000 (11,500,000)

*Figures not developed. Item needs further investigation. This total reflects 1975 dollar value. [1] The number of ventures in both bays was a coarse estimate based on protection and ease of establishment of venture. It does not take into consideration the availability of the site for its intended purpose.

This value also does not include satellite industries or ancillary businesses which are developed in response to the primary industry.

It is recommended that a detailed planning study of this phase be undertaken to identify the numbers of sites available for each type of operation, the extraction of fishery statistics for analysis in terms of losses, estimation of satellite and ancillary businesses, market potential for each species and current state of the art in each species.

Dr. B.E. Barrett

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE,

That the Board of Engineers for Rivers and Harbors, created under the provisions of Section 3 of the Rivers and Harbors Act approved June 13, 1902, be, and is hereby, requested to review the report on Passamaquoddy-St. John River Basin Power Project, Maine transmitted to Congress by the President of the United States on July 12, 1965 published as House Document No. 236, 89th Congress, and other pertinent reports, with a view to determining the current feasibility, taking full advantage of the latest technological advances, of the Passamaquoddy Tidal Power Project in the interest of providing tidal power, recreation, economic development and related land and water resources purposes.

Adopted: March 21, 1975

Jennings Randolph
Jennings Randolph, Chairman.

(At the request of Edmund S. Muskie, Senator from Maine)

ATTACHMENT NO. 3

ATTACHMENT NO. 4

REFERENCES

The following references have been utilized in preparing the latest updated project cost estimate and benefits in this economic feasibility report:

1. Report to the International Joint Commission by the International Passamaquoddy Engineering Board, titled: Investigation of the International Passamaquoddy Tidal Power Project, dated October 1959, with nineteen (19) appendices.

2. Report of the International Joint Commission, Docket 72, Investigations of the International Passamaquoddy Engineering and Fisheries Board, titled: Investigation of the International Passamaquoddy Tidal Power Project, dated April 1961.

3. Report from Secretary, Department of the Interior, dated July 1963, titled: The International Passamaquoddy TIDAL POWER PROJECT and UPPER SAINT JOHN RIVER Hydroelectric Power Development.

4. Supplement to July 1963 Report, The International Passamaquoddy TIDAL POWER PROJECT and UPPER SAINT JOHN RIVER Hydroelectric Power Development dated August 1964, prepared by Passamaquoddy - Saint John River Study Committee.

5. Corps of Engineers Manual EM 1110-2-1302, dated 1 November 1967 with Change 1 dated 10 February 1972, titled: Engineering and Design, COST ESTIMATES, Government Estimate of Fair and Reasonable Cost to Contractor.

6. Corps of Engineers Manual EM 1110-2-1301, dated 17 March 1972, titled: Engineering and Design, COST ESTIMATES, Planning and Design Stages.

7. Several miscellaneous project quantity surveys and cost estimates for the tidal project, prepared during the general period 1957-1963, are in the New England Division in their original engineering computation form.

8. Water Resources Council (WRC) regulations, December 1968.

9. Water Resources Development Act of 1974, 7 March 1974.

10. Senate Document No. 97, 87th Congress, entitled: Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for use and Development of Water Related Land Resources.

11. Senate Resolution 148.

12. Resolution adopted on 21 March 1975 by the Committee on Public Works, United State Senate as sponsored by Edward S. Muskie, Senator from Maine.

13. Public Law 94-180, Public Works Appropriations Act for Fiscal Year 1976 approved on 26 December 1975.

14. Results of revised construction engineering, operations and maintenance cost estimate prepared for the Corps of Engineers, New England Division by the firm of Stone and Webster Engineering Corporation, under NED Contract No. DACW33-76-C-0081 dated 28 April 1976.

15. Letter from Federal Power Commission, New York, dated 12 August 1976 containing updated power information for the project.

16. Memorandum dated 10 August 1976 and Supplemental Report No. 1 thereto from NED Real Estate Division on revised costs for Lands and Damages.

17. Memorandum dated 26 August 1976 from NED Planning Division on revised benefits derived from the project for recreation .

18. Memorandum dated 4 October 1976 from NED Planning Division on revised benefits derived from the project for area redevelopment.

19. Report entitled "An Environmental Assessment Report," dated 8 March 1976 prepared by Enviro-Sciences, Inc. for the proposed 250,000 BPD Fuels Refinery and Deepwater Marine Terminal at Eastport, Maine, USA.

20. Preliminary proposal, undated, entitled: Passamaquoddy Marine Resources Development by the Passamaquoddy Tribe, Community Development Office, Pleasant Point, Perry, Maine.

21. Memorandum dated 1 November 1976 from NED Planning Division on benefits derived from fisheries and mariculture.

ATTACHMENT NO. 5

SUPPLEMENT
TO PRELIMINARY
ECONOMIC FEASIBILITY STUDY
FOR
INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT
COBSCOOK AND PASSAMAQUODDY BAYS
MAINE AND NEW BRUNSWICK

Prepared by

New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

29 April 1977

SUPPLEMENT TO SYLLABUS (4/29/77)

Subsequent to the economic evaluation of the proposed international tidal power plan prepared in accordance with conventional methods of analyzing water resource projects, the New England Division performed two additional tasks which are included in the attached Supplemental Report dated 29 April 1977. These items are (1) evaluating the 500 MW international plan on a "life-cycle costing" basis, and (2) evaluating various tidal power plans which are completely within the boundaries of the United States including the original 1935 plan and various alternatives proposed about that time.

Analyzing the 500 MW international tidal power project from a life-cycle costing viewpoint, it appears that the benefits from power alone would greatly exceed the costs over the 100 year life span of the project. The study, principally accomplished by FPC, indicated that after the first twenty years of operation, the annual power benefits would commence to exceed the annual costs of the project and the Benefit-Cost Ratio would be greater than 1.0 based on an annual escalation rate of 5%. Additional ancillary benefits which could be derived such as area redevelopment, fisheries-mariculture, and recreation would further increase the desirability of the project from an economic standpoint. There is no doubt that if some of the All-American plans were evaluated on a life-cycle basis, they would also show greater power benefits than costs over the life spans of the projects. The tidal power project deserves worthwhile consideration in that it complies with many principles, strategies and goals of President Carter's Energy Program.

An analysis of various All-American one and two pool tidal power concepts indicate that their Benefit-Cost Ratio based on power benefits alone ranges between 0.31 and 0.45. If ancillary benefits are included, the Benefit-Cost Ratio could increase to 0.55 to 0.77. The Total Investment Cost of the projects vary from $274,045,000 to $635,022,000 and the annual electrical generation is bdtween 292,000,000 and 615,000,000 kilowatt-hours.

In conclusion, it appears that all tidal power projects evaluated in the Passamaquoddy region under this study effort and the separate ERDA study, utilizing the conventional method of analysis, are not economically feasible under present conditions and that further study is not warranted. Viewing tidal power from a life-cycle basis, the anticipated power benefits could be expected to greatly exceed the costs over the 100 year life span of the project, however, to officially evaluate the project by this method may require legislation.

TABLE OF CONTENTS (Supplement)

<u>PLATES</u>

TABLES

ATTACHMENTS

I. INTRODUCTION

During the latter stages of the preparation of the 30 November 1976 report which reported the estimated costs, benefits and economic feasibility of the International Tidal Power Project, two other elements of work arose which required additional investigation and study. These items were:

a. Analyze the international tidal power project on a life-cycle costing method which utilizes variable costs and considers price escalation for fuels, operation and maintenance, etc. over the life of the project. (Requested by Hon. James B. Longley, Governor of Maine).

b. Investigate and analyze a tidal power plan which would be entirely within the United States (All American Plan) and identical or similar to the project for which construction was started in 1935 and stopped in 1936 before the project was completed.

One of the reasons for investigating the All-American Plans was that informal information indicated that the Canadians might not be too interested in developing tidal power in the Passamaquoddy Region since they possess better tidal power sites in the upper sections of the Bay of Fundy. Some of their preliminary investigations indicate that they can generate more electricity and at less construction cost. In the fall of 1976, their initial work concluded that the results of preliminary study warranted further study on the subject.

The alternative projects being evaluated herein are completely within the boundaries of the United States in Cobscook Bay and are of the single and two-pool concepts.

In the current re-evaluation, each of the major construction items have been re-estimated and annual costs computed. The estimated annual benefits which can be derived from the project have also been tabulated. In addition, some project modifications have been considered and their description and cost are included.

II. SUPPLEMENTAL INFORMATION

Sections III through VI of this Supplemental Report pertain to the All-American tidal power plans and Section VII presents the Life-Cycle Cost Study. The Supplemental Summary and Recommendations are included in Section VIII.

The work under this supplemental phase of study was accomplished by the following:

Participant	Assignment/Task
Federal Power Commission	Preparing data, providing and running the computer model for "life-cycle" costing
New England Division	
Engineering Division	Preparing up-to-date construction cost estimates of All-American tidal power plans, study management, coordination, technical input, and report preparation
Planning Division	Area Redevelopment, Recreational and Fisheries Benefits
Real Estate Division	Prepare up-to-date costs for Lands and Damages

III. DESCRIPTION OF ALL AMERICAN PLANS

A. Single Pool System

The project selected in 1936 was known as "Plan D" and utilized Cobscook Bay as a high pool with the powerhouse discharging water into Western Passage. Although considered in the original plan, pumped storage facilities were not included in the construction of the project.

Three basic alternative plans of development were initially considered. Each plan employed the same general principle involving a single tidal pool and auxiliary pumped storage plant and reservoir or an auxiliary (diesel) generator to supply continuous power, but differing in methods of utilization.

Specifically, the plans were:

Plan 1 - Cobscook Bay developed as a low level pool with one-way flow through the turbines. In this plan, power generation would occur on the incoming tide as soon as the difference in levels between the ocean and low pool exceeded approximately 5½ feet and would continue through the rising and falling tide until the difference in head between the ocean and the low pool again reaches 5½ feet. A pump storage plant was to be located at Haycock Harbor. Emptying gates would be opened to empty the bay to approximately low tide level. This plan of development contemplated the continued use of Cobscook Bay as a low level pool in the ultimate international two pool project.

Plan 2 - Cobscook Bay developed as a high level pool with one way flow through the turbines. In this plan, the generation of power would start on the outgoing tide when the head differential exceeds 5½ feet and would continue through the low tide and the incoming tide until the difference in level between the high pool and the ocean again reaches 5½ feet.

A system of filling gates would be opened to refill the bay to approximately high tide level.

Plan 3 - Cobscook Bay developed as a high level pool with provision in initial structures for flow in either direction. This plan is similar to plan 2 with the exception that provision is made in initial structures for utilizing Cobscook Bay as either a high or low level pool initially and/or ultimately. The power station would be designed with reversible flow turbines and the filling/emptying gate structures would be designed for flow in either direction.

All plans initially proposed to include 10 generating units with provision for installing 10 additional units at a later date. The 10 units would be 15,000 kw each with a total flow rate of 160,000 cfs. The water wheel generators would operate when the tidal head difference was 5½ feet and above for a period of approximately 7 hours each tidal cycle. The pumped storage plants were to be provided as auxiliary means of power generation to supplement the tidal plant. Subsequently, turbine/generator unit sizes were changed and a flow of 78,000 cfs was determined necessary for the 10 generating units.

The average annual output of power for Plan 2 was 257,000,000 kwh of continuous power, and increased to 340,000,000 kwh with 100% load factor when the pumped storage facility was eliminated, however, power supply was intermittent.

Plan 2 was recommended for construction on 14 September 1935. However, the project was re-evaluated and various other alternatives were presented. An alternative known as "Plan D" was finally recommended and approved in May 1936. This plan is basically Plan 2 with the following major modifications:

a. Deletion of pumped storage facilities at Haycock Harbor.

b. Reducing the number of hydro turbine/generators from 10 to 5 in the tidal power plant.

c. Adding a 30,000 kw diesel auxiliary power plant.

d. Reducing the generator sizes from 15,000 kw to 12,500 kw each. The annual electrical production was estimated at 308,000,000 kwh in lieu of the 257,000,000 kwh for Plan 2.

In 1934 the Dexter Cooper organization endeavored to obtain a loan from the Public Works Administration but the application was disapproved. In the interim, the Maine State Planning Board recommended adoption of the project as a Federal project. Subsequently, an allotment of $10,000,000 was approved by President Franklin D. Roosevelt from the Emergency Relief Appropriation of 1935 for initiation of the project.

B. Description of 1935-1936 Project (Plan D) (See Plate 1)

Construction Components

The plan provided for a power plant with 5-10,300 HP vertical turbine/generator units 12,500 kw each totaling 62,500 kw, and a 30,000 kw diesel auxiliary power plant.

The total estimated gross annual output was 308 million kwh. Future expansion of the facility called for 10-12,500 kw units. The project was based on one-way flow using Cobscook Bay as a high pool. Other major items besides the power plant were:

- Filling gates (On Treat Island) (12 each) (30'x30' venturi type)
- Navigation Lock (On Treat Island) (56'x360')
- Dams:
  - Carlow Island (Completed) (1,500')
  - Pleasant Point (Completed) (2,700')
  - Eastport (3,400')
  - Treat-Dudley (Started but not Completed)
  - Lubec (3,800')

Construction Costs

The total project cost estimate dated 22 May 1936 in the amount of $37,985,250 is shown in Table No. 1.

Energy Production

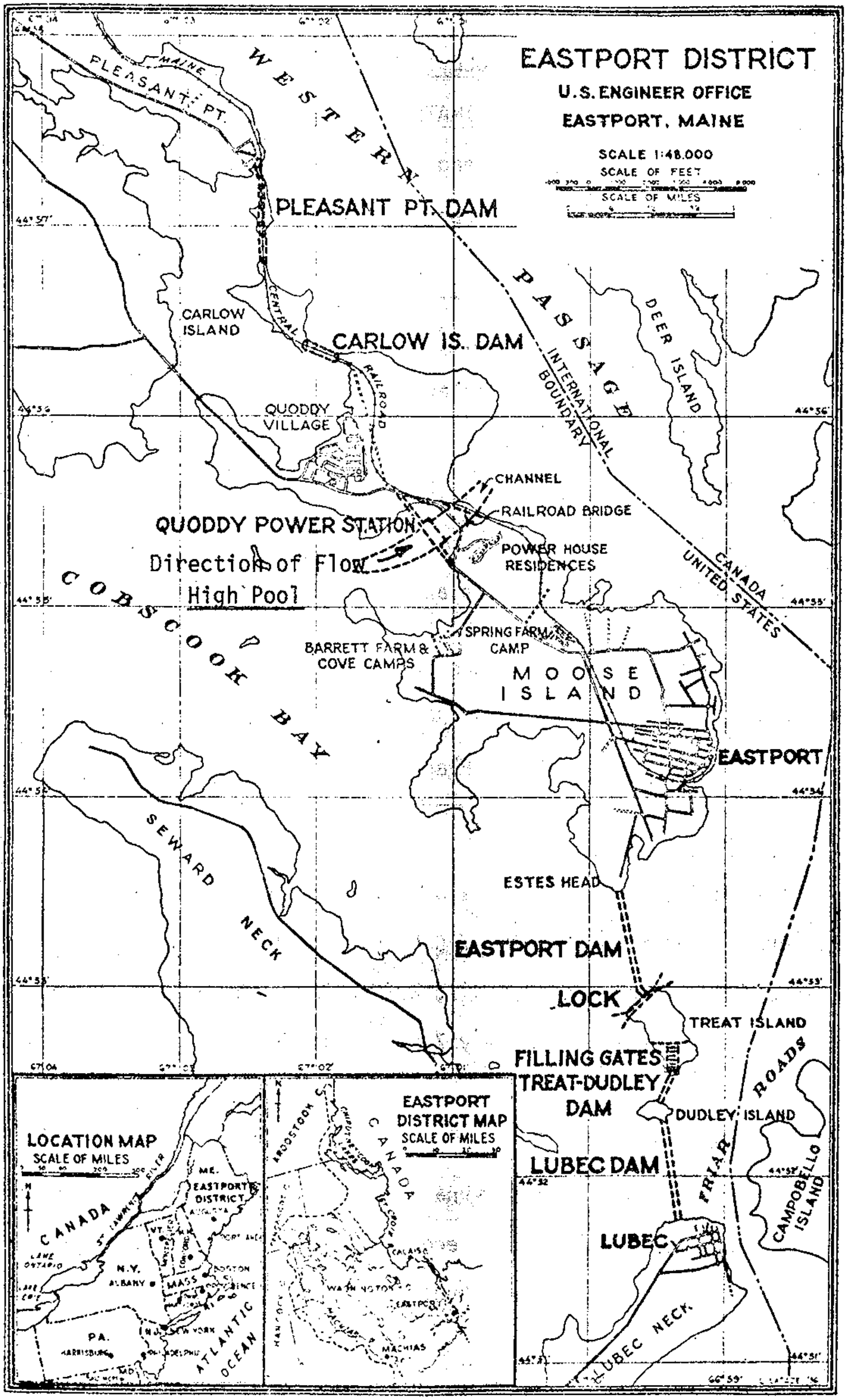
The total gross energy production was estimated to be 308,000,000 kwh .

Annual Charges

The annual charges were estimated to be $2,409,760 for the installation.

Corps of Engineers Responsibilities

The Corps of Engineers was assigned to accomplish the engineering, design, construction, supervision and administration, and real estate aquisition activities for the project under the direction of the District Engineer, United States Engineer Office, Eastport, Maine.



1935-1936 All American Plan "D" (Single Pool) PLATE 1

TABLE 1

REVISED ESTIMATE PLAN D

(Including all Overhead by Project Items)

(22 May 1936 price levels)

Item 1	Eastport Dam	$ 8,091,510
Item 2	Lubec Dam	3,967,600
Item 3	Navigation Lock - Treat Island	1,129,700
Item 4	Carlow Island Dam	216,000
Item 5	Pleasant Point Dam	295,100
Item 6	Treat-Dudley Island Dam	334,000
Item 7	Filling Gates (In Treat Island, 12 Unit - 2/3 Capacity with Sill at Elev. -25.0)	5,214,900
Item 8	Powerhouse at Carryingplace Cove - 5 Unit	14,868,540
Item 9	Diesel or Steam Auxiliary (30,000 kw)	3,867,900
	Total - Revised Estimate Plan "D"	$37,985,250

Power Hydraulics

The project was based on a one-way flow principle of tidewaters passing through the powerhouse from Cobscook Bay into Western Passage, an entrance to Passamaquoddy Bay. It was estimated that water flow through each turbine would be approximately 7,800 cubic feet per second at an average head of 12 feet.

C. Two-Pool Systems

Early in 1936, four alternate two-pool plans within Cobscook Bay were investigated and the most economical of the four was submitted with initial and annual costs, power output and benefits. A comparison was also made with single pool Plan D as described earlier. This two-pool plan was designated as Plan #4. Two-pool plan #4, shown on Plate 2, consisted of the following features:

a. An inter-pool dam 12,000 feet long from Leighton Point to Razor Island to Seward Neck with a small navigation lock and 5 unit (40 MW) powerhouse.

b. Six 60 foot open-type filling gates and a 1000-foot wide filling channel cut to -30 feet m.s.l. across Seward Neck.

c. Outer-pool dam, 4,200 feet long from Shackford Head to Seward Neck, with six 60 foot open type emptying gates and a 56'x360' navigation lock.

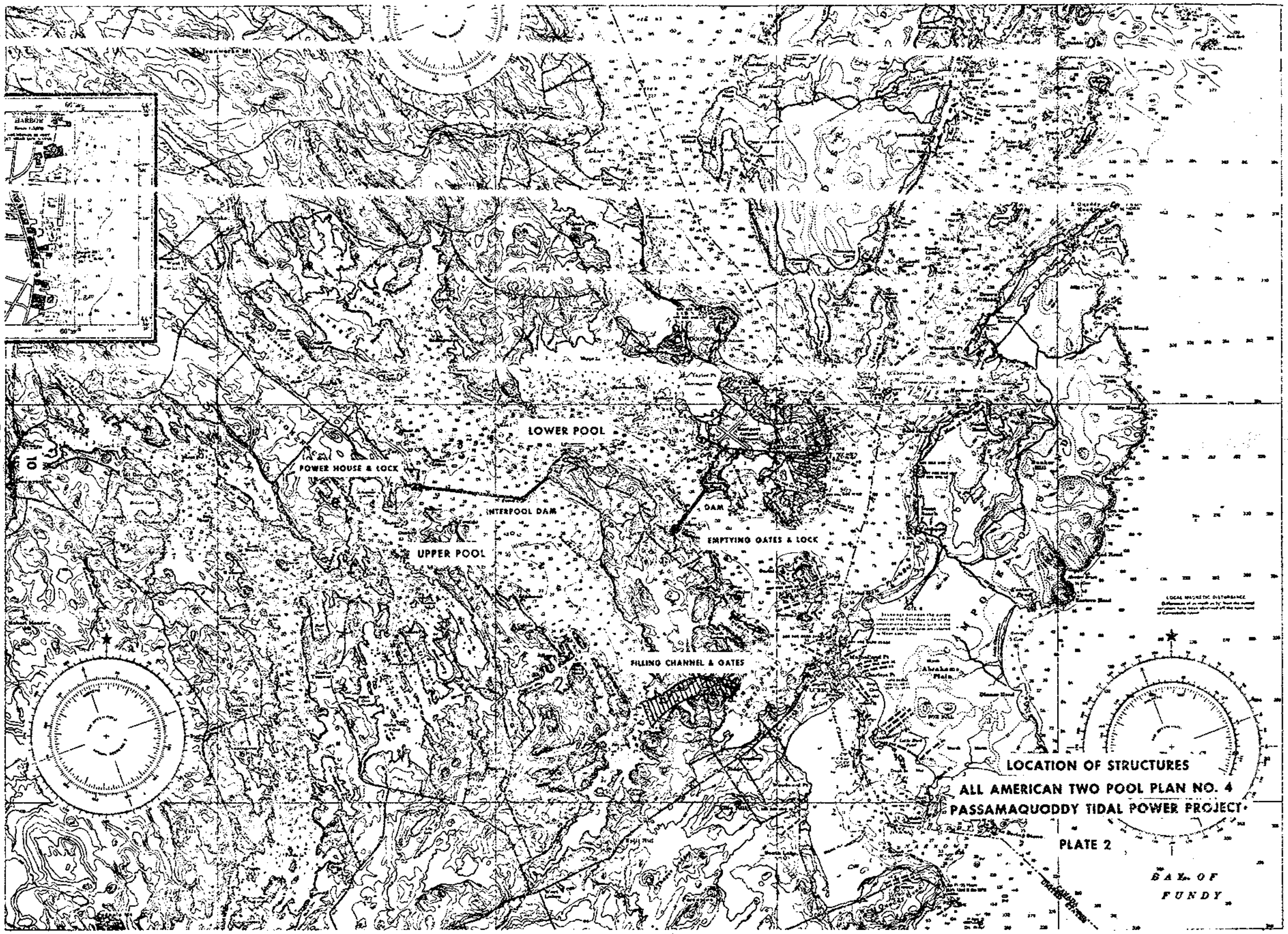
The three alternate locations for the dams, locks, and powerhouse that were to divide Cobscook Bay into two pools are summarized as:

Alternate 1 - Inter-pool dam with lock and powerhouse from Leighton Point to Denbow Point and the outer pool dam with lock and emptying gates from Shackford Head to Seward Neck. This plan would also require a dam across South Bay and a filling channel across Seward Neck and from Federal Harbor into straight bay.

Alternate 2 - Inter-pool dam with lock and powerhouse from Leighton Point to Seward Neck and the outer pool dam with lock and emptying gates from Estes Head to North Lubec by way of Treat, Dudley and Rogers Islands.

Alternate 3 - Inter-pool dam with lock and powerhouse from Birch Point to Seward Neck with the outer pool dam located as in Plan #2.

Sketch type layouts of the miscellaneous alternatives and plans in Cobscook Bay are shown on Attachment No. 4.


LOWER POOL
POWER HOUSE & LOCK
INTERPOOL DAM
DAM
EMPTYING GATES & LOCK
UPPER POOL
FILLING CHANNEL & GATES
BAY OF FUNDY
LOCATION OF STRUCTURES
ALL AMERICAN TWO POOL PLAN NO. 4
PASSAMAQUODDY TIDAL POWER PROJECT
PLATE 2

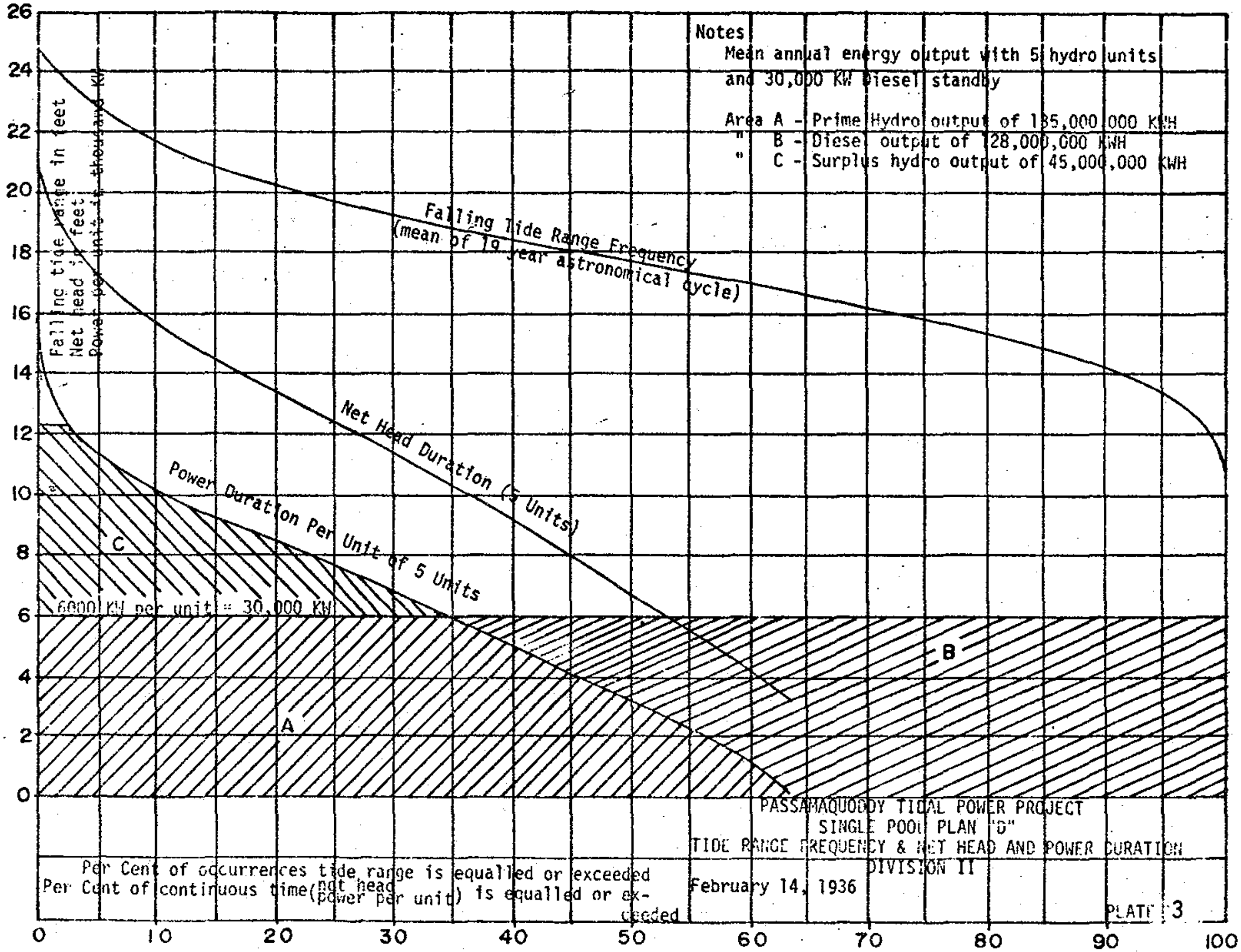
In the above plans, including Plan #4, the inner portion of Cobscook Bay would be utilized as the high level pool. The change in pool area with the change in tidal stage is greater in this portion of Cobscook Bay than the outer part. Also, a substantially greater length of shoreline may be adversely affected if the inner basin were operated as the low pool. Some mud flats may be exposed with low tide basin development.

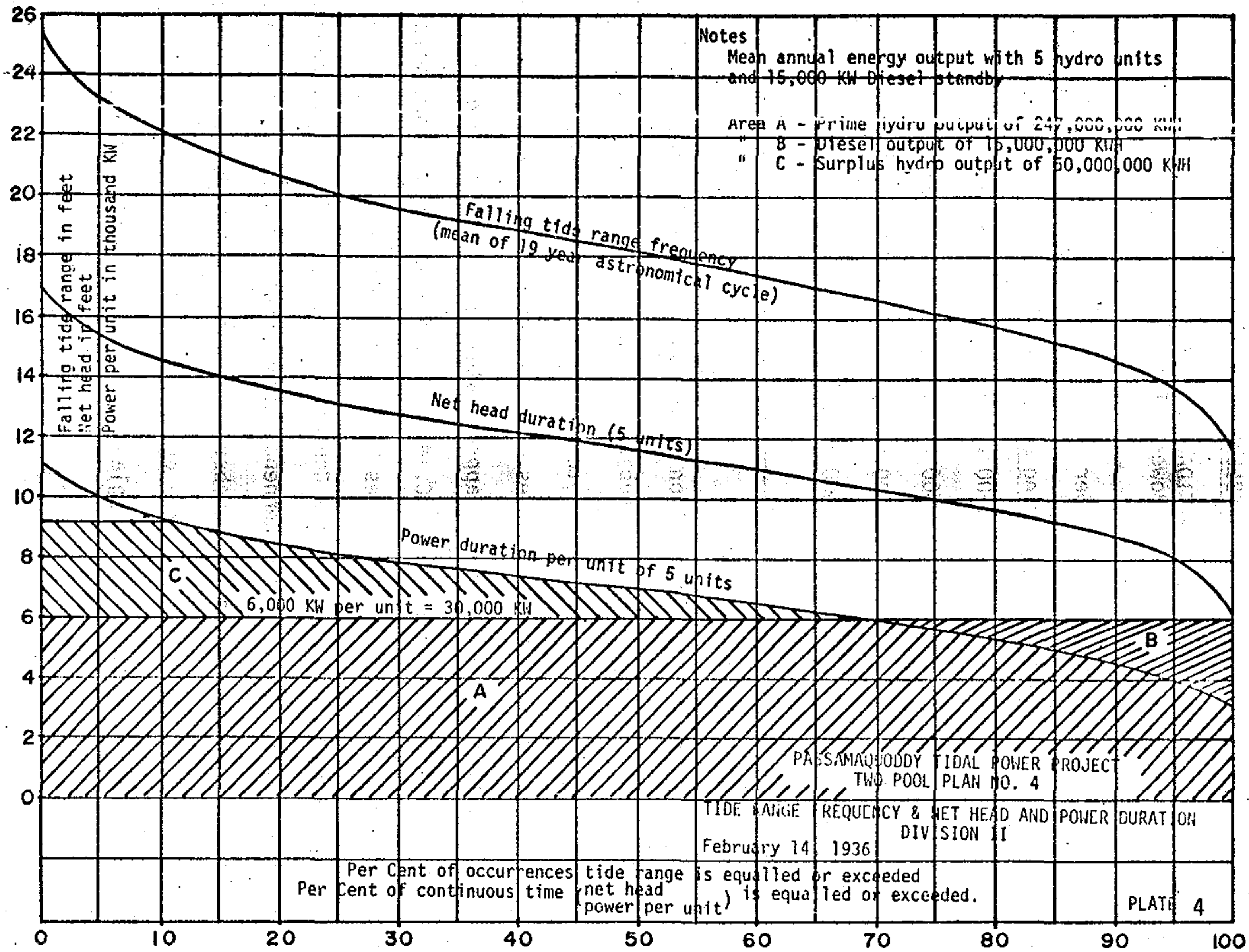
D. Power Generation (1936 Concept)

In 1936 the plan of power generation was to supply 30,000 kw of power 100% of the time as shown by the curves in Plate 3 (Plan D) and Plate 4 (Plan #4). Any output above the 30,000 kw was considered surplus. The diesel auxiliary was to firm power at the site whenever there was insufficient hydraulic head between the upper and lower pools for power generation. Since 1936, however, the concept of auxiliary at-site power went out of date with the formation of the regional system of NEPOOL where the tidal plant would stand strictly on its own.

Plan D required a 30,000 kw auxiliary because of the intermittent operational characteristics of a single-pool system. The two-pool Plan #4 could produce power continuously but at varying amounts, therefore, only a 15,000 kw auxiliary was required.

Table 2 shows the capacity and estimated annual net energy output of each single and two-pool plan. The annual energy output shows energy from tidal power alone. Output from auxiliary sources are not included.


Notes
Mean annual energy output with 5 hydro units and 30,000 KW Diesel standby
Area A - Prime Hydro output of 185,000,000 KWH
" B - Diesel output of 128,000,000 KWH
" C - Surplus hydro output of 45,000,000 KWH
Falling tide range in feet
Net head in feet
Power per unit in thousand KW
Falling Tide Range Frequency (mean of 19 year astronomical cycle)
Net Head Duration (5 Units)
Power Duration Per Unit of 5 Units
6000 KW per unit = 30,000 KW
A
B
C
26
24
22
20
18
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
Per Cent of occurrences tide range is equalled or exceeded
Per Cent of continuous time (net head / power per unit) is equalled or exceeded
PASSAMAQUODDY TIDAL POWER PROJECT
SINGLE POOL PLAN "D"
TIDE RANGE FREQUENCY & NET HEAD AND POWER DURATION
DIVISION II
February 14, 1936
PLATE 3



PASSAMAQUODDY TIDAL POWER PROJECT
TWO POOL PLAN NO. 4

TIDE RANGE FREQUENCY & NET HEAD AND POWER DURATION
DIVISION II

February 14, 1936

PLATE 4

TABLE 2

ALL AMERICAN TIDAL POWER PROJECT
(Tidal Power Only)

Plan	Number of Pools	Number of Generating Units	Annual Net Energy Output in kwh (Tidal Power Only)
Plan D	1	5 (12,500 kw ea)	180,000,000
Plan D	1	10 (12,500 kw ea)	341,000,000
Plan D	1	20 (12,500 kw ea)	615,000,000
Plan #4	2	5 (8,000 kw ea)	292,000,000

E. Power Consumption

The use and integration of the smaller All American tidal power plants would have to be subject of further study by interested agencies, the power companies, etc. in the New England area.

For comparison purposes, the two pool All American Plan without auxiliary will produce approximately 292,000,000 kwh of electricity annually and the S.C. Moore hydro plant in New Hampshire on the Connecticut River produces 251,000,000 kwh each year. The existing Comerford Plant on the Connecticut River produces 307,000,000 kwh, the Wyman Plant on the Kennebec River produces 320,000,000 kwh, and the Weldon Plant on the Penobscot produces 110,000,000 kwh annually.

To briefly present the general electrical production and requirements scenario in New England, the following data is also included:

a. <u>Forecast of Total Electric Power Consumption in New England*</u>

Year	Annual Kilowatt-Hours	L.F.
1974	82,787,000,000 (actual)	62.2
1985	183,613,000,000	62.1
2000	363,704,000,000	62.3

*Extracts from NEEPS, July 1973.

b. <u>New England System Capability</u> (Winter-Megawatts)*

	1977/1978	1986/1987
Total Capability	29,950 MW	30,631 MW
Total Peak Load	15,217 MW	24,379 MW
% Reserve before Maint.	44.2%	25.6%
Est. Peaking Capacity (20%)	4,000 MW	6,000 MW

*Extracts from NEPLAN, 1 Jan 1977. (See attachments 1 and 2).

c. According to the Electrical Utility Industry in New England Statistical Bulletin of 1975, the net energy generated in Maine in 1975 was 7,650,000,000 kwh and the total energy sales to ultimate customers in Maine in 1975 was 6,328,000,000 kwh.

IV. <u>ESTIMATED PROJECT COSTS</u> (All American Plans)

A. <u>Construction Cost Estimates</u>

Table 3 shows the total construction cost of the All American single and two pool plans.

The estimates are based on the following criteria:

1. The 1936 project cost, column 1, was tabulated for comparison purposes. Project costs shown in this column were developed by taking the direct government costs of 1936 and adding 23% for contractor

overhead and profit. The costs of Carlow Island and Pleasant Point dams were not included since they were already built in 1936.

2. Column 2 is a June 1976 cost estimate of the 1936 project (Plan D).

3. The tabulated costs, columns 2 through 6, are based on wage rates and material costs as of 30 June 1976. Contractors' overhead and profit of 23% are included.

4. A contingency factor of 15% was utilized for all labor, materials and equipment.

5. The tidal power project layout concept is basically the same as the 1936 project.

6. The allowance for government costs which cover engineering and design (E&D), supervision, inspection and administration (S&A) during construction has been estimated at 10%.

7. The construction period for either single or two pool plans with the 5 and 10 unit powerhouse structures were estimated at 3 years, and the 20 unit plan was estimated at 4 years. Plan D in 1936 was scheduled for completion in 4 years.

8. Construction methods, equipment and materials proposed in the 1959 International Passamaquoddy Tidal Power Project report and other reports were similar to those that would be used in an All American Plan today.

9. The project is based on a 100-year life.

10. An annual interest rate of 6-3/8% for return on investment and interest during construction. The 6-3/8% interest rate has been retained in accordance with Engineer Circular 11-2-126 dated 20 July 1976.

11. It was estimated that one quarter of major mechanical equipment would have to be replaced every 30 years.

12. It was considered that the project will have total Federal funding and that there would be no non-Federal investments.

13. Service equipment in the 10 and 20 unit powerhouse plans include such items as tugs, derrick boat, mobil crane, etc. These were carried separately since their replacement rate is more frequent during the 30-year period.

B. Project Annual Costs

The estimated total annual costs for the five All American plans are shown in Table 4. Annual interest and amortization charges are based on the prevailing interest rate for water resource projects of 6-3/8% and project life of 100 years. Operation and maintenance costs include fuel, labor, supplies and miscellaneous equipment. Major replacements make allowance for 25% of the turbines, speed increasers, governors, generators, exciters, filling and emptying gates and lock gates to be replaced every 30 years during the life of the project.

PASSAMAQUODDY TIDAL POWER PROJECT COSTS
ALL-AMERICAN PLANS

Project Features	"PLAN D" VARIATIONS (1 pool)				"PLAN 4" VARIATONS (2 pools)	
	1936 Project Cost (1)	5-12,500 KW units with 30,000 KW aux. (2)	10-12,500 KW units with No aux. (3)	20-12,500 KW units No aux. (4)	5-8,000 KW units with 15,000 KW aux. (5)	5-8,000 KW units No aux. (6)
1. Dams*	10,795,000	40,524,000	33,199,000	31,599,000	45,609,000	45,609,000
2. Navigation Locks	1,028,000	7,962,000	7,962,000	7,962,000	12,500,000	12,500,000
3. Filling & Emptying Gates	4,749,000	40,588,000	40,588,000	57,500,000	32,850,000	32,850,000
4. Power House	14,033,000	98,930,000	175,166,000	334,088,000	74,100,000	74,100,000
5. Auxiliary Power	3,690,000	14,400,000	-	-	7,800,000	-
6. Service Facilities	-	-	880,000	1,000,000	-	-
7. Relocations	-	-	7,144,000	9,619,000	-	-
8. Fishways	-	-	2,000,000	2,000,000	3,000,000	3,000,000
9. Filling Channel	-	-	-	-	28,800,000	28,800,000
10. Sub-Total	34,295,000	202,404,000	266,939,000	443,768,000	204,659,000	196,859,000
11. Contingency 15%	5,144,000	30,361,000	40,040,000	66,565,000	30,699,000	29,529,000
12. Sub-Total	39,439,000	232,765,000	306,979,000	510,333,000	235,358,000	226,388,000
13. E&D and S&A 10%	-	23,276,000	30,698,000	51,033,000	23,536,000	22,639,000
14. Sub-Total	-	256,041,000	337,677,000	561,366,000	258,894,000	249,027,000
15. Real Estate (includes 20% Contingency)	-	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000
16. Service Equipment	-	-	533,000	746,000	-	-
17. Total Construction Cost (First Cost)	39,439,000	257,141,000	339,310,000	563,212,000	259,994,000	250,127,000
18. Interest During Construction	-	24,589,000	32,447,000	71,810,000	24,862,000	23,918,000
19. Total Investment Cost	-	281,730,000	371,757,000	635,022,000	284,856,000	274,045,000

*Pleasant Point and Carlow Island Dams are constructed.

TABLE 3

PROJECT ANNUAL COSTS
(June 1976 Price Levels)

	5-12,500 kw units w/30,000 kw aux. Single Pool (1)	10-12,500 kw units no aux. Single Pool (2)	20-12,500 kw units no aux. Single Pool (3)	5-8,000 kw units w/15,000 kw aux. Two Pool (4)	5-8,000 kw units no aux. Two Pool (5)
Total Investment Cost					
Construction Cost	$257,141,000	$339,310,000	$563,212,000	$259,994,000	$250,127,000
Interest During Construction	24,589,000	32,447,000	71,810,000	24,862,000	23,918,000
Total Investment	$281,730,000	$371,757,000	$635,022,000	$284,856,000	$274,045,000
Annual Costs					
Interest & Amortization	$ 17,997,000	$ 23,748,000	$ 40,565,000	$ 18,197,000	$ 17,506,000
Operation & Maintenance	6,142,000	815,000	1,129,000	3,531,000	718,000
Major Replacements	153,000	324,000	601,000	118,000	95,000
Total Annual Costs	$ 24,292,000	$ 24,887,000	$ 42,295,000	$ 21,846,000	$ 18,319,000

TABLE 4

V. PROJECT BENEFITS

A. General

The international and/or All-American tidal power projects, whatever size evaluated, are basically proposed for the purpose of producing saleable electric power. Power benefits are the primary basis for evaluating the project and are displayed for each of the five All-American plans previously described. In addition, other ancillary benefits from area redevelopment, fisheries-mariculture, and recreation will be derived from construction of the project. The following Table paragraphs discuss the anticipated benefits:

TABLE 5

Summary of Benefits

Type of Benefits	All-American Plans Estimated Annual Benefit Values (1)	(2)	(3)	(4)	(5)
Power	$ 8,123,000	$ 7,693,000	$13,874,000	$ 8,605,000	$ 8,244,000
Area Redevelopment	3,670,000	4,555,000	7,219,000	3,702,000	3,660,000
Fisheries-Mariculture	1,834,000	1,834,000	1,834,000	1,834,000	1,834,000
Recreation	375,000	375,000	375,000	375,000	375,000
Totals	$14,002,000	$14,457,000	$23,302,000	$14,516,000	$14,113,000

B. Power Benefits

The production and sale of electric power would account for the greatest part of the project benefits and should, over a period of time, provide the entire revenue for the project cost repayment, including interest. Annual energy generation quantities were taken from the 1935 to 1937 Passamaquoddy Tidal Power Development Studies which provided a comprehensive scoping of single and two pool tidal arrangements. Although modes of operation may differ somewhat if the project were to be completely restudied today, it is believed that these figures are appropriate for this report. Table 6 shows the value of tidal power used to compute power benefits. The selection of capacity and energy values for a single pool system were arrived at from the following observations:

Any single pool tidal power plan would provide energy generation as a function of the lunar cycle - and different than that of the solar cycle. The lack of storage-generation control causes generation out of phase with the electrical load and accordingly, the time availability of energy would vary daily. Generation cannot be relied upon at all times. Consequently, no power would be firm on the load in the traditional sense, and the value of the tidal plant would be limited. Therefore, the tidal plant would have practically no capacity value.

Tidal power generation, on the other hand, would be entirely predictable, renewable, and nearly independent of the climatic variables of a traditional hydropower installation. Scheduling of generation could be made months in advance. The tidal plant's role would seem to be best as a "fuel saver", a producer of maximum energy whenever it occurs, allowing those plants with the highest associated fuel costs to shut down when tidal power is available. The value of this intermittent energy would be directly dependent on the generation mix in the NEPOOL system.

Today, the generation mix includes all types of plants - nuclear, oil and coal-fired steam, combined-cycle, gas turbines and hydro (conventional and pumped-storage). With the exception of nuclear, it is believed that, at one time or another, any of the types would be in a position in the New England load to be replaced by tidal power in the NEPOOL system, and therefore, the value of the tidal power as replacement should reflect a conglomerate of all types of system fuel costs. An exact value for this weighted conglomerate cost is difficult to define but a June 1976 price level value for the tidal power of 24 mills ($.024) per kilowatt-hour seems reasonable for this study. This is meant to represent an average cost for all fossil fuel derivative generating types.

The two pool unit values in Table 6 are the same as those used for the 500 MW International Project (10% private financing only for benefit-cost computation). In many respects its operational characteristics could be considered similar to those of the larger International project.

TABLE 6

Passamaquoddy Tidal Power Project
All-American Plans
At-Market Unit Power Values
(June 1976)

Item	Unit	Unit Value Single Pool	Unit Value Two Pool
Capacity Value*	$/kw/yr.	0	45.00
Energy Value	mills/kwh	24.0	24.0

*Single pool systems do not have dependable capacity therefore no capacity value was given.

The following table (Table 7) summarizes the total annual power benefits that would be realized from each plan. Transmission losses of eight percent for capacity and six percent for energy were assumed.

TABLE 7

Passamaquoddy Tidal Power Project
All-American Plans
Annual Project Power Benefits
(June 1976 Price Levels)

Plan	Capacity (MW)	Net Energy (GWH)	Annual Benefit ($/yr)
(1) Plan D w/5 units & 30,000 kw auxiliary	62.5	305	$ 8,123,000
(2) Plan D w/10 units no auxiliary power	125	341	$ 7,693,000
(3) Plan D w/20 units no auxiliary power	250	615	$13,874,000
(4) Plan #4, 2 pool w/5 units & 15,000 kw auxiliary	40	308	$ 8,605,000
(5) Plan #4, 2 pool w/5 units, no auxiliary power	40	292	$ 8,244,000

C. Recreation Benefits

It is considered that the value of benefits from recreation would be approximately the same for each of the smaller All-American tidal power projects as for the larger international plans. The estimated present annual U. S. dollar value is $375,000 based on 300,000 visitor days per year and a daily rate of $1.25 per day. This annual visitation does not appear to be abnormal as it is our understanding that in 1975 the La Rance, France, tidal power project attracted approximately 300,000 tourists.

D. Fisheries-Mariculture Benefits

The construction of "All-American" tidal power plants, those which can be constructed entirely within the boundaries of the United States, would preclude damming and impounding the waters of

Passamaquoddy Bay which is mostly in Canada. The All-American projects are also within the limits of Cobscook Bay, approximately 41 square miles in area and the evaluation of fisheries benefits are therefore limited to this bay. As noted under the international plans, Cobscook Bay has active fisheries with a total annual value of $1,400,000. With the construction of a tidal power project in Cobscook Bay it is felt that more advantageous conditions would prevail for fishing and development of mariculture practices, although there would be some fisheries losses realized. It is estimated that there would be an annual gain through mariculture of $3,500,000 and a possible annual fisheries loss of $1,666,000 for a net benefit of $1,834,000. It is considered that this annual dollar benefit would apply to any of the five(5) All-American tidal projects considered.

E. Area Redevelopment

The background for any of the All-American plans evaluated is basically the same as previously mentioned for the international tidal power plans. Assumptions for estimating the AR benefits are based on construction cost plus contingencies, that local labor will be 75% of the total labor cost (27%) of the total project cost, 3 year construction period (4 years for plan with 20 unit powerhouse), a 6 3/8% interest rate, and applicable operation, maintenance and replacement costs.

The following table presents the estimated Area Redevelopment benefits for each plan:

TABLE 8

All-American Plans
Estimated Annual Area Redevelopment Benefits

	Plans				
	(1)	(2)	(3)	(4)	(5)
Area Redevelopment	$3,670,000	$4,555,000	$7,219,000	$3,702,000	$3,660,000

VI. PROJECT ECONOMICS (All American Plans)

A. General

This section of the report summarizes the project economics with the benefit to cost ratio method of analysis.

The benefit-cost ratio results from a comparison of all project annual benefits of power, recreation, area redevelopment and fisheries-mariculture with total project annual costs. Annual costs include interest and amortization (6-3/8% and 100-year repayment period), operation and maintenance and major equipment replacements. The results of the above figures expressed as a quotient indicates the relative merit of a project.

B. Benefit-Cost Ratios

Table 9 summarizes the benefit-cost ratio computations for the five plans and all are below unity. However, a comparison of B/C ratios clearly shows which are closer to unity, therefore, more economical with this method of analysis.

PASSAMAQUODDY TIDAL POWER PROJECT
ALL AMERICAN PLANS
BENEFIT-COST RATIO ANALYSIS

	Plan D 5 - 12,500 KW generators with 30,000 KW aux. (1)	Plan D 10 - 12,500 KW generators w/o aux. power (2)	Plan D 20 - 12,500 KW generators w/o aux. power (3)	Plan #4 2 pool w/5 8,000 KW generators & 15,000 KW aux. (4)	Plan #4 2 pool w/5 8,000 KW generators w/o aux. gen. (5)
Total Investment Cost	$281,730,000	$371,757,000	$635,022,000	$284,856,000	$274,045,000
Capacity MW	62.5	125	250	40	40
KWH/yr*	305,000,000	341,000,000	615,000,000	308,000,000	292,000,000
Total Annual Benefits	14,002,000	14,457,000	23,302,000	14,516,000	14,113,000
Annual Power Benefits**	8,123,000	7,693,000	13,874,000	8,605,000	8,244,000
Total Annual Costs	24,292,000	24,887,000	42,295,000	21,846,000	18,319,000
Total Annual Benefits / Total Annual Cost	0.58	0.58	0.55	0.66	0.77
Annual Power Benefits / Total Annual Cost	0.33	0.31	0.33	0.39	0.45
Total Investment Cost / KW	$ 4,508	$ 2,974	$ 2,540	$ 7,121	$ 6,851

*Net Annual Salable Energy

**Includes Transmission Losses of 8% for Capacity (where applicable) and 6% for Energy.

TABLE 9

VII. LIFE-CYCLE COSTING STUDY

Economic Analysis of the International Tidal Power Project by the "Life-Cycle Costing" Method

A. Background

By letter dated 7 September 1976, the Honorable James B. Longley, Governor of Maine, strongly suggested that the International Passamaquoddy Tidal Power Project be analyzed on a life-cycle cost basis. Letter dated 24 September 1976 from the New England Division informed the Governor that such an analysis would be developed for his use, however, that it was not the conventional dictated method as established by the Congress for the evaluation of water resource projects. Copies of both letters are included as attachments 6 and 7 to this report.

For accomplishing the "life-cycle" costing, it was decided to utilize the computer model as described in Chapter VI of U.S. Department of Commerce, National Technical Information Service Report AD/A-018 359, dated July 1975, titled: "Hydroelectric Power Potential at Corps of Engineers Projects." The model is operational and is operated by the Federal Power Commission, Washington, D.C.

On 29 November 1976, the New England Division confirmed request for the Federal Power Commission, New York Regional Office, to furnish the necessary expertise and accomplish the life-cycle cost study by utilizing the computer model in their Washington office. On 12 January 1977 a joint FPC-NED conference was held in the FPC offices in New York to review the proposed work, discuss input parameters and variables to be incorporated in the study.

The following definition which appropriately explains Life-Cycle Costing has been extracted from the General Provisions of Armed Services Procurement Regulation dated 21 May 1976: "The Life-Cycle Cost of a system or item of equipment is the total cost to the Government of acquisition and ownership of that system or item of equipment over its full life. It includes the cost of development, acquisition, operation, support and where applicable, disposal. Since the cost of operating and supporting the system or equipment over its useful life is substantial and, in many cases, greater than the acquisition cost, it is essential that such costs be considered in development and acquisition decisions in order that proper considerations can be given to those systems or equipment that will result in the lowest life cycle cost to the Government."

The project selected for analysis by the life-cycle costing method is the 500 Megawatt International Passamaquoddy Tidal Power Project. Since the purpose of the project is Power, the analysis is based on power only and its benefits; and effects of ancillary benefits such as area redevelopment, recreation and mariculture have not been incorporated.

B. Methodology

In utilizing the computer model various applicable parameter inputs were included for the tidal power project and its most probable alternative, a combined cycle plant. Annual escalation rates of 3, 5 and 7 percent were selected to reflect a range of possible increases in costs for items subject to rise such as labor, materials, replacements and fuel during the operation and maintenance period. Annual costs such as amortization, depreciation and interest on investment remain constant and are not variable items. The sharp jumps in the curves representing the alternative (Plates 5 through 8) result from fixed depreciation charges based on earlier lower costs which are inadequate for replacement of worn-out plant and equipment. The actual cost of replacement escalated at a rate compounded annually over the 30 year life of the alternative. In kind replacement was assumed for the alternative.

Separate model runs were executed for the 500 MW international tidal power project and the selected alternative. For this report the life-cycle data has been condensed, briefly described and summarized by utilizing charts and graphs so as to simplify presentation.

C. <u>Discussion of the Life-Cycle Study and Results</u>

Based on a 100-year project life and assuming that the 500 Megawatt International Passamaquoddy Tidal Power Project went on line in June 1976 with annual costs of $121,121,000 for producing 1,932,000,000 kwh/year, Plates No. 5, 6 and 7 show the projected annual costs based on annual compounded escalation rates of 3, 5 and 7%. For comparison purposes both the alternative and tidal power projects are financed at 6-3/8%. The charts also show the estimated annual benefits from power produced by the tidal power project, commencing with $55,316,000 in June 1976. In escalating the power benefits at similar rates the annual benefits will increase faster than the annual costs of the tidal power plant.

It can be seen that the line projections for annual power benefits and costs ultimately intersect after a period of project operation. The B/C ratio becomes 1.0 to 1.0 at the intersection and increases each year thereafter. The following indicates the year that the B/C ratio equals 1.0:

Escalation Rate	Year BCR = 1.0
3%	31
5%	20
7%	15

If the annual power benefits of $64,286,000 for a privately financed combined cycle alternative plant are used the Benefit Cost Ratio of 1.0 is reached as follows:

Escalation Rate	Year BCR = 1.0
3%	30
5%	18 (See Plate 8)
7%	13

The "crossover point" where the annual power benefits equal the annual charges and the Benefit Cost Ratio becomes 1.0 to 1.0, indicates the year in which the project becomes profitable to operate. The principal reason that the benefits (costs of alternative) ultimately surpass the annual costs for the tidal project is that tidal power does not rely on a fuel for generating electricity as does the alternative combined cycle plant.

From the data used to produce Plates 5 through 7 the total present worth and annual cost were computed and tabulated in Table 10. The last column in Table 10 shows how the Benefit Cost Ratio, based on power benefits only, is affected by various rates of escaltion. The higher the rate of escalation the larger the B/C ratio.

Plate 9 shows that with the circumstances in Table 10 a Life-Cycle B/C ratio of 1.0 is achieved with an escalation rate of approximately 4.0%. From this analysis it appears that the alternative would be favored with an escalation rate below 4.0% and tidal power with a rate above 4.0%.

Although life-cycle costing was not accomplished herein for any of the All-American Plans there is no doubt that the results would be similar from a life-cycle analysis viewpoint. Inasmuch as the Corps was reporting on life-cycle costing for the international plan, ERDA proposed to accomplish such studies on miscellaneous All-American Plans in their report. Their study indicates that the All-American Plans evaluated by them are economically feasible when evaluated by this type of analysis.

The preliminary life-cycle costing study contained herein is based principally on general inflationary trends. If further study on the project is continued, a detailed life-cycle study involving both general and relative escalation trends should be accomplished.

TABLE 10

Life-Cycle Analysis of
500 MW International Tidal Power Project
(Both Plants Financed at 6-3/8%)

Interstate	Escalation Rate	Plant Type	Total Present Worth (6-3/8% Discount Rate)	Annual Cost (Using CRF 100 Yrs. 6-3/8%)	Levelized Cost (Mills/ KWH)	Life Cycle B/C Ratio (Power Benefits)
6-3/8%	3%	Alternative	$1,491,758,000	$ 95,294,000	49.3	.76
6-3/8%	3%	Tidal	1,958,832,000	125,130,000	64.8	
6-3/8%	5%	Alternative	2,731,104,000	174,463,000	90.3	1.32
6-3/8%	5%	Tidal	2,072,210,000	132,373,000	68.5	
6-3/8%	7%	Alternative	6,531,940,000	417,260,000	216.0	2.70
6-3/8%	7%	Tidal	2,420,867,000	154,645,000	80.0	

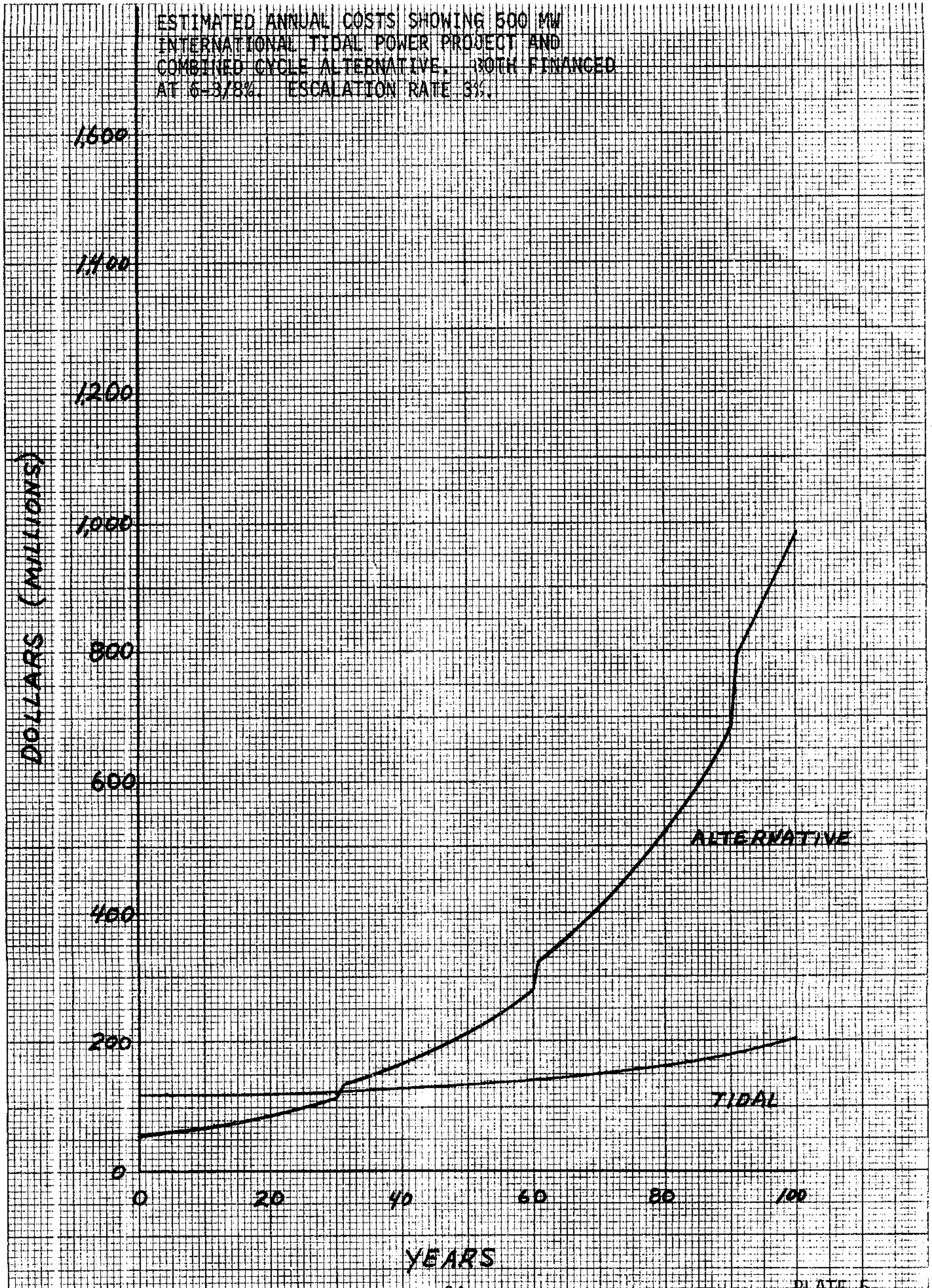

ESTIMATED ANNUAL COSTS SHOWING 500 MW INTERNATIONAL TIDAL POWER PROJECT AND COMBINED CYCLE ALTERNATIVE. BOTH FINANCED AT 6-3/8%. ESCALATION RATE 3%.
1,600
1,400
1,200
1,000
800
600
400
200
0
DOLLARS (MILLIONS)
ALTERNATIVE
TIDAL
0
20
40
60
80
100
YEARS

PLATE 5

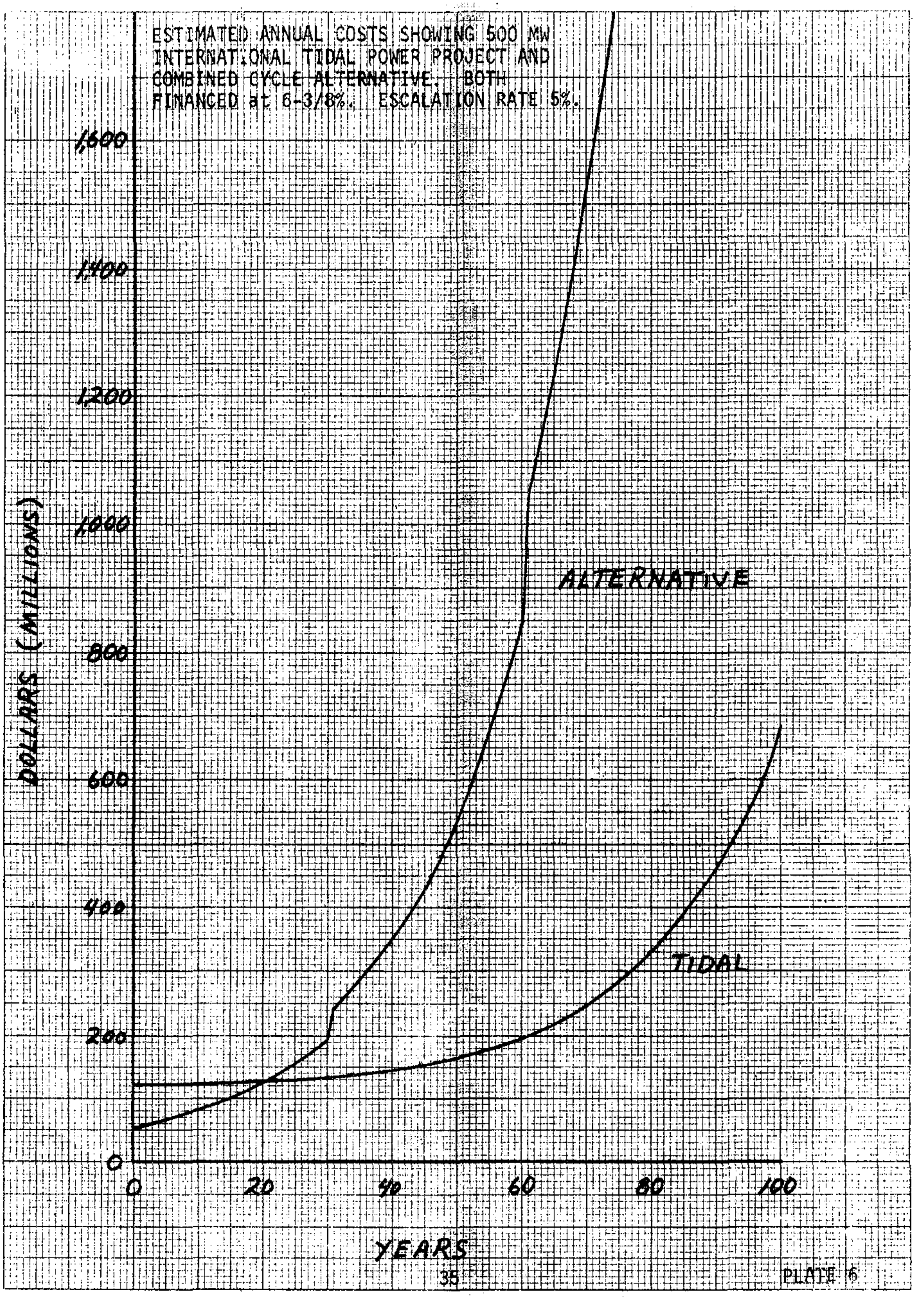
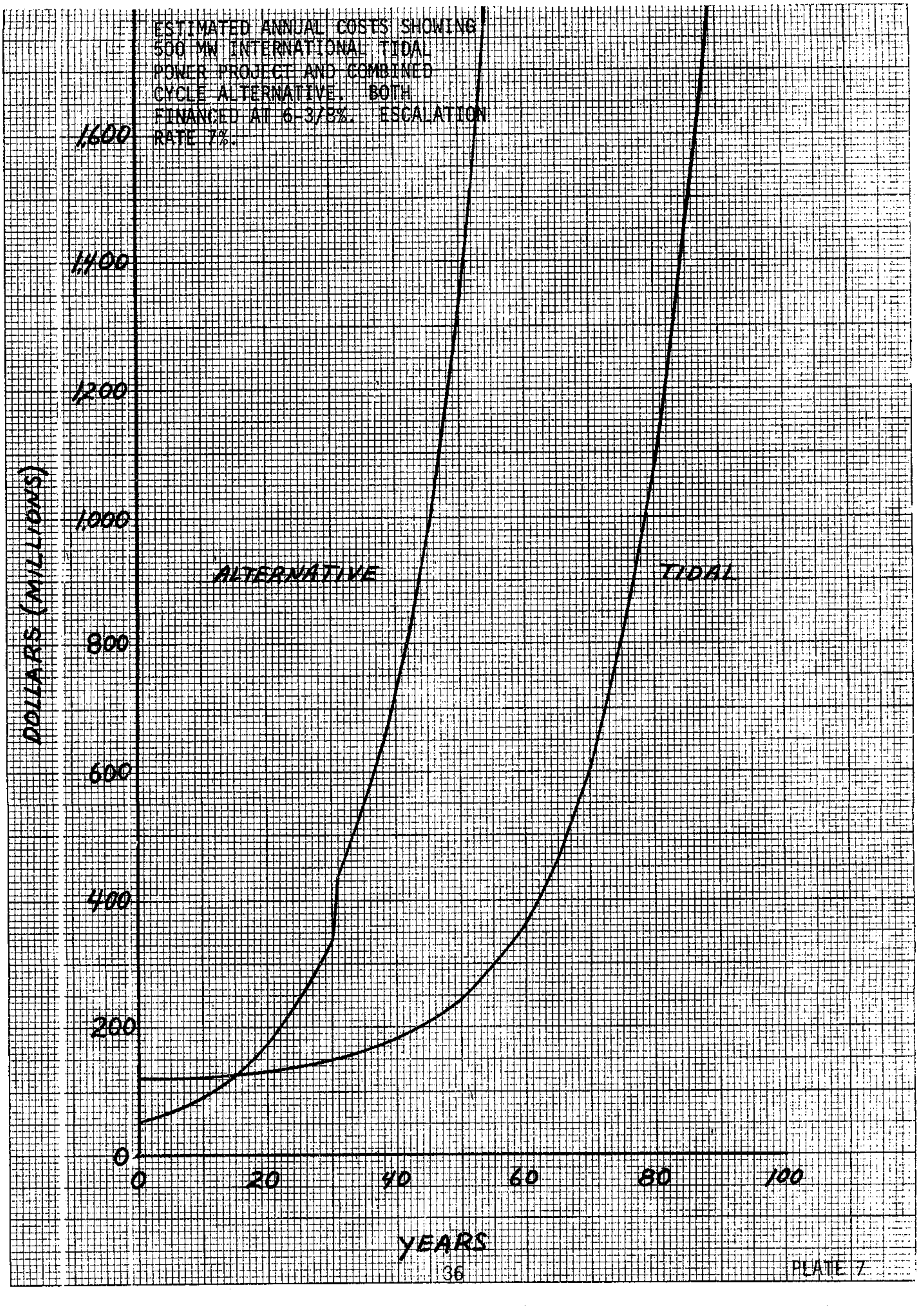
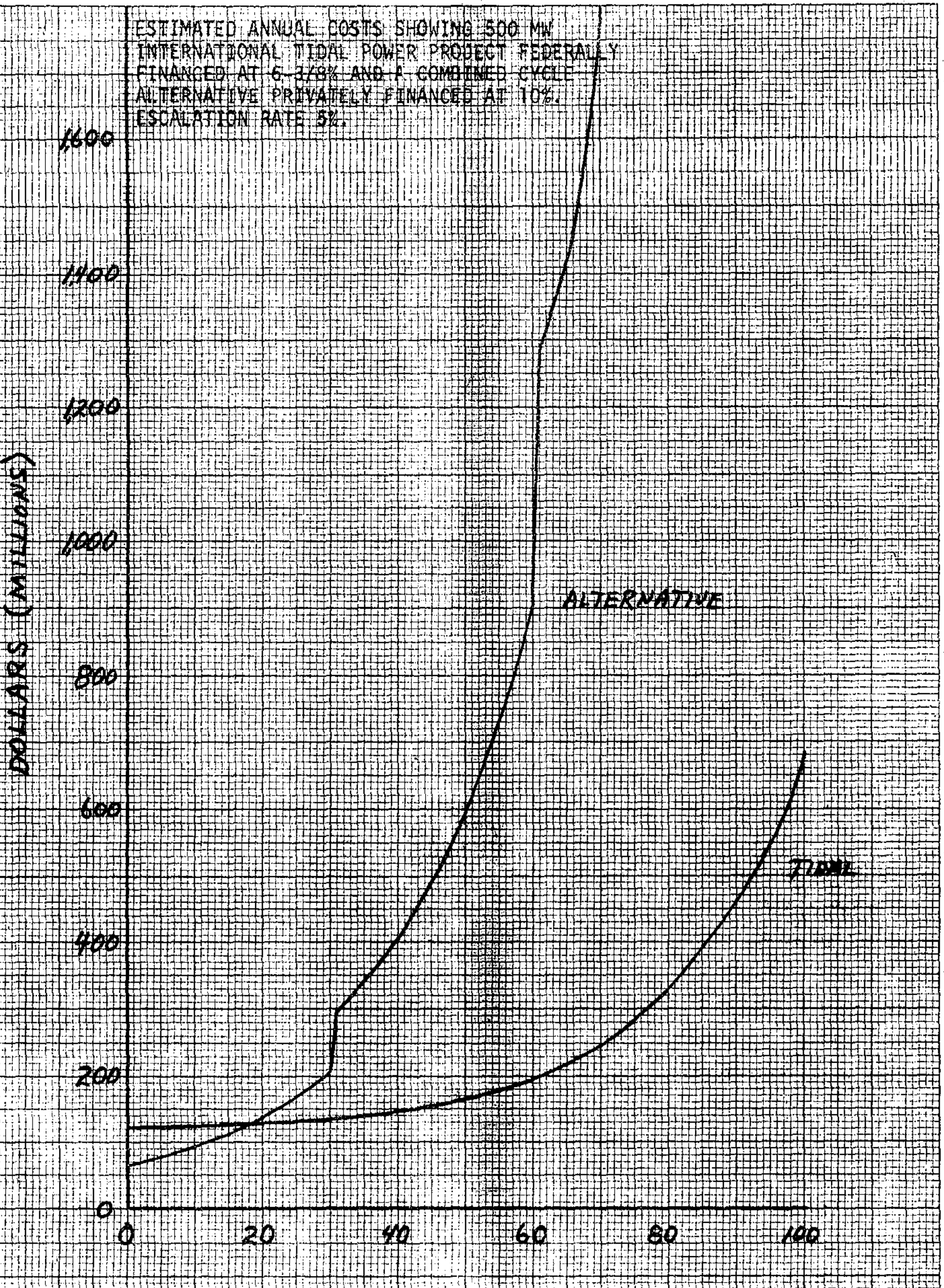

ESTIMATED ANNUAL COSTS SHOWING 500 MW
INTERNATIONAL TIDAL POWER PROJECT AND
COMBINED CYCLE ALTERNATIVE. BOTH
FINANCED at 6-3/8%. ESCALATION RATE 5%.
DOLLARS (MILLIONS)
1,600
1,400
1,200
1,000
800
600
400
200
0
ALTERNATIVE
TIDAL
0
20
40
60
80
100
YEARS

PLATE 6



ESTIMATED ANNUAL COSTS SHOWING 500 MW INTERNATIONAL TIDAL POWER PROJECT AND COMBINED CYCLE ALTERNATIVE. BOTH FINANCED AT 6-3/8%. ESCALATION RATE 7%.
DOLLARS (MILLIONS)
1,600
1,400
1,200
1,000
800
600
400
200
0
ALTERNATIVE
TIDAL
0
20
40
60
80
100
YEARS

PLATE 7



ESTIMATED ANNUAL COSTS SHOWING 500 MW INTERNATIONAL TIDAL POWER PROJECT FEDERALLY FINANCED AT 6-3/8% AND A COMBINED CYCLE ALTERNATIVE PRIVATELY FINANCED AT 10%. ESCALATION RATE 5%.
DOLLARS (MILLIONS)
1600
1400
1200
1000
800
600
400
200
0
ALTERNATIVE
TIDAL
0
20
40
60
80
100
YEARS

PLATE 8

LIFE-CYCLE B/C RATIO
VS. PERCENT ESCALATION

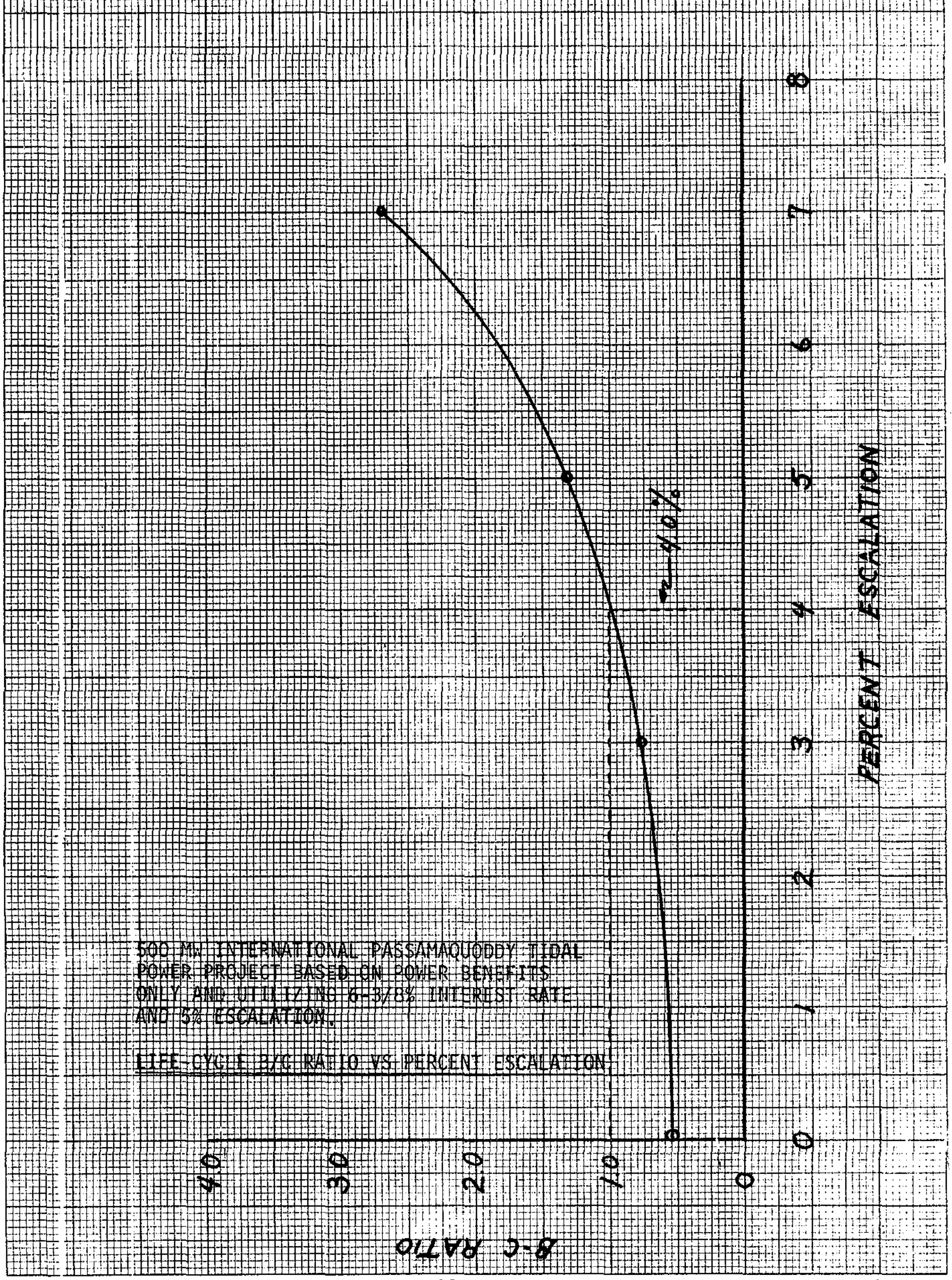


PLATE 9

VIII. SUPPLEMENTAL SUMMARY FINDINGS AND RECOMMENDATIONS

A. Summary and Findings

1. The estimated Total Investment Cost of the All-American Plans, which includes Construction Costs and Interest During Construction, varies between $274,045,000 and $635,022,000; and the estimated annual electrical generation of the concepts range from 292,000,000 to 615,000,000 kilowatt-hours.

2. The conventional benefit-cost analysis for the All-American Plans based on 30 June 1976 price levels, and the life-cycle evaluation of the 500 MW International Plan are based on prices and predictions of the same period.

3. The benefit-cost ratio for the All-American Plans, considering power benefits only, varies between 0.31 and 0.45. This ratio increases to a range of 0.55 and 0.77 when anticipated ancillary benefits of area redevelopment, fisheries-mariculture and recreation are included. In comparison, the B-C Ratio of the 500 and 1000 MW International Plans ranged from 0.53 to 0.49, respectively, and when the ancillary benefits were included the B-C ratios were 0.74 and 0.67, respectively.

4. Utilizing the Total Investment Cost, the cost of installed power on a per kilowatt basis varies between $2,540 and $7,121 for the five All-American Plans considered.

5. The construction of any one of the All-American Plans would not entail in-depth negotiations, international agreements, considerations, etc. which the international plans would require. However, activities in informational service on project planning, engineering and impacts

as well as coordination on the project in general with Canada would be appropriate. All electrical power generated from an All-American Plan would be utilized within the United States.

6. The results of the ERDA study indicate that tidal power development is not economically feasible in the Passamaquoddy region when evaluated on the conventional method of analysis for water resource projects, however, evaluation on a life-cycle basis makes the project worthwhile over its life span.

7. The All-American tidal power plans are very much smaller than the international plans and it appears that the two pool 40 Megawatt concept in Cobscook Bay is the most desirable one of the American plans. This plant will produce 292,000,000 kilowatt-hours of electricity annually which is equivalent to an alternate combined-cycle plant requiring about 408,000 barrels of oil per year, as compared to the 2,700,000 barrels of oil per year saved by the 500 MW international plan producing 1,932,000,000 kilowatt-hours per year.

8. <u>Proposed Oil Refinery and Marine Terminal in Eastport</u>

With respect to the proposed Pittston Company oil refinery and marine terminal in Eastport, Maine, a public hearing on the draft Environmental Impact Statement was jointly held by the Corps of Engineers and Environmental Protection Agency on 3 December 1976 in Eastport, Maine. Currently, additional information is being prepared for inclusion in the final Environmental Impact Statement by the Environmental Protection Agency, Region I.

In the event the refinery is constructed before the tidal power project, larger navigational locks will have to be provided than originally planned for the tidal project.

If the use of 70,000 DWT tankers is permitted, the navigation lock at Head Harbor Passage will have to be increased in size from 415' x 60' x 21' draft to approximately 830' x 120' x 42' draft. This will increase the initial construction and total investment costs, the annual charges, and will lower the benefit-cost ratio for the overall tidal power project. Similar changes will occur if 250,000 DWT tankers are allowed which will require the navigation lock to be increased in size from 415' x 60' x 21' draft to approximately 1250' x 180' x 67'. Construction costs for a lock which will accommodate a 150,000 DWT tanker were not computed but it appears that such a lock would reduce the B-C ratio to .69. The following table illustrates the estimated changes in BCR for the 500 MW international tidal power project with various size locks included:

TABLE 11

CHANGES IN BCR (WITH VARIOUS LOCK SIZES)

Basic 500 MW Project with Navigation Lock	Total Project Investment Cost*	Total Annual Charges	Total Annual Benefits	Benefit-Cost Ratio
With Basic Lock:				
415'x60'x21'	$1,829,937,000	$121,121,000	$89,674,000	.74 to 1.00
With Larger Lock:				
830'x120'x42'	$1,916,380,000	$126,617,000	No change	.71 to 1.00
1250'x180'x67'	$1,971,104,000	$132,499,000	No change	.68 to 1.00

*Includes Transmission Costs

The updated construction costs, annual charges and benefits, and economic analysis for the All-American Plans do not include additional costs required for larger navigational locks to accommodate the VLCC's or tankers enroute to the proposed refinery and marine terminal. The various All-American tidal power concepts often have different locations for the dam structures and navigational locks. In summary, if the Oil Refinery and Marine Terminal is constructed, the Passamaquoddy Tidal Power Project will have to provide larger navigational locks as noted under the following concepts:

International Tidal Power Project

Under the 1959-1964 International Tidal Power Project, the basic lock at Head Harbor Passage was 415'x60'x21' draft. If either the 500 or 1000 Megawatt power facilities are constructed, a navigation lock in the 1250'x180'x67' range will have to be constructed to accommodate the 150,000-250,000 DWT VLCC's proposed for carrying crude oil to the refinery and the 70,000 DWT tankers used for carrying finished products from the plant. These larger locks would be located in Head Harbor Passage at Campobello Island, Canada.

All-American Tidal Power Projects

If these tidal power projects are proposed, the following navigation locks would be required to provide waterborne access to the refinery:

TABLE 12

NAVIGATIONAL LOCKS FOR ALL-AMERICAN

TIDAL POWER ALTERNATIVES

All-American Tidal Power Concept	Original Lock Required	New Proposed Lock Required	Size of VLCC (DWT)	Possible Lock Location (Dam)
		Single Pool		
Plan D	360'x56'x21'	1250'x180'x67'	70-250,000	Treat Island
1	"	"	"	"
2	"	"	"	"
3	"	"	"	"
		Double Pool		
1	360'x56'x21'	830'x120'x42'	70,000	Cooper Island
2	"	1250'x180'x67'	70-250,000	Treat Island
3	"	"	"	"
4	"	830'x120'x42'	70,000	Cooper Island

Note: On each of the 2-pool plans, an additional interpool lock (probably 95'x25'x12') will be required for small commercial and recreational craft.

~~As indicated previously in~~ this supplemental report, the Benefit-Cost Ratio would be reduced for the 500 MW tidal power project if larger navigational locks are provided in Head Harbor Passage. Likewise, the Benefit-Cost Ratio for any of the All-American Plans will be reduced when larger size navigation locks are included. A preliminary estimate of the Benefit-Cost Ratio reduction for power only based on proportionment is as follows:

TABLE 13

REVISED BCR FOR SELECTED ALL-AMERICAN CONCEPTS

All American Tidal Power Concept	Total Invest. Cost with Basic Lock	Total Invest. Cost with Larger Locks	(Power Only) Estimated BCR with Basic Lock	(Power Only) Estimated BCR with Larger Locks
		Single Pool		
Plan D w/5 units	281,730,000	422,897,000	0.33	0.22
Plan D w/10 units	371,757,000	512,924,000	0.31	0.22
Plan D w/20 units	635,022,000	776,189,000	0.33	0.27
		Double Pool		
Plan 4 w/Aux.	284,856,000	371,299,000	0.41	0.31
Plan 4 w/o Aux.	274,045,000	360,488,000	0.45	0.34

Notes: 1. Plan D requires a lock approximately 1250'x180'x67' at a Total Investment Cost of $141,167,000.

2. Plan 4 requires a lock approximately 830'x120'x42' at a Total Investment Cost of $86,443,000.

9. Results of Tidal Power Study by Energy Research and Development Administration (ERDA).

Preliminary indications from this study (in final completion stages) on tidal power by the Energy Research and Development Administration and their consultant, Stone & Webster Engineering Corporation, are that the concepts they evaluated are not economically feasible utilizing the conventional economic analysis method and current price levels. Their study resulted in Benefit-Cost Ratios between 0.32 and 0.50 to 1.00 when only the power benefit was considered. When estimated area redevelopment, fisheries and recreation benefits were incorporated, the B-C ratio increased to 0.48 through 0.69 to 1.00. These ancillary benefits were furnished by the New England Division.

The tidal power concepts evaluated in the ERDA report in the Passamaquoddy region are:

Concept No.	Size	Name	No. Pools	Concept Layout
M-1	500 MW	International	2	(1964 Layout)
M-2	1000 MW	International	2	(1964 Layout)
M-3	180 MW	All-American	1	(1935 Plan Layout)
M-4	180 MW	All-American	1	(Shackford Head-Cooper Island)

The analysis of the M-3 concept, a variation of the 1935 Plan, by life cycle costing methods indicated that to obtain a Benefit-Cost Ratio of 1.00, a fuel cost rise of 5.2 to 5.4% per year would be needed. The slight difference in percentage is whether or not pumped storage backup facilities are provided.

Their notation on the economic feasibility of the tidal power projects in Maine indicated that:

"Considering power facilities only, it is necessary to have a benefit-cost ratio of at least 1.00. Under these conditions, the proposed tidal power projects would not be worthy of any further consideration. However, with the diminishing U. S. supplies of oil and natural gas, and the strong prospects of continually rising prices for these fossil fuels, life cycle cost analyses certainly appears to offer a better means for evaluating the feasibility of tidal power projects."

As a matter of information, their evaluation of possible tidal power projects in Alaska shows that the power benefits are much lower than those obtained for the tidal projects in Maine. The Benefit-Cost Ratios for power at the Alaskan sites considered vary between 0.15 and 0.31 to 1.00. These lower ratios are attributed to higher construction costs in Alaska and lower estimated fuel costs for the "alternative" coal-fired plant.

Following is a brief preliminary comparison of the separate tidal power economic studies accomplished by the Energy Research and Development Administration and the Corps of Engineers in the Passamaquoddy region:

a. By Conventional Method of Analysis (for Power only)*

	Benefit Cost Ratio (BCR)	
Project	Corps	ERDA
500 Megawatt International Plan	0.53 to 1.00	0.50 to 1.00
1000 Megawatt International Plan	0.49 to 1.00	0.32 to 1.00
Typical All-American Plans	0.31-0.45 to 1.00	0.36-0.51 to 1.00

b. By Life-Cycle Costing Method (for Power only)*

Project Evaluated	Corps Findings
500 Megawatt International Plan	Project will commence to be cheaper to operate than an oil fired alternative after the 20th year based on a 5% compounded escalation rate and 6-3/8% financing rate.
	ERDA Findings
180 Megawatt All-American Plan	Project will commence to be cheaper to operate after 13 years than an oil fired alternative based on a 5.5% fuel rise per year and interest rate of 7%.

*Ancillary benefits of area redevelopment, fisheries-mariculture and recreation are not included. It is noted that all possible tidal power concepts in Cobscook/Passamaquoddy Bay were not studied by life-cycle analysis, however it is felt that most plans would be economically feasible when evaluated by this method, some sooner than others.

10. Another separate study on tidal power is being conducted by Office of Technical Assessment, Congress of the United States. Preliminary information of their draft report entitled, "Tidal Power," dated February 1977, indicates that a tidal power project in the vicinity of Passamaquoddy and Cobscook Bays may be attractive for development if fuel costs for thermal plants continue to escalate, and that the project should be evaluated and justified on the life-cycle costing method.

11. Relationship of Passamaquoddy Tidal Power Project with the President's Energy Program of 20 April 1977.

Reference: Text of Fact Sheet on the President's Program issued by White House Energy Staff, 20 April 1977.

The following is based on a preliminary review of the referred to Energy Program Fact Sheet and contains comments on the relationship of the Passamaquoddy Tidal Power Project to the energy program. The Sections of the program are listed with comment as follows:

I. National Energy Policy, Principles, Strategies and Goals.

A. Principles:

· The project conserves petroleum, a natural resource.

· The project causes limited environmental impacts. There would be practically no air, noise, land or water pollution. There would be some aquatic, terrestial and wetlands impacts caused by the tidal pools. There would be no solid or liquid waste disposal problems.

· The national and regional vulnerability to embargoes and uncertain supplies would be reduced.

B. Strategy:

• Dependency on foreign oil is reduced.

• The project operates on development of a new, dependable, renewable and inexhaustible source of energy -- tidal power.

• The project helps to sustain economic growth.

• The project affords an opportunity to implement the natural resource conservation program.

C. National Energy Goals:

• The project would help the nation in reducing foreign oil imports.

• Allows further conservation of domestic energy sources.

II. Effects of the President's Energy Plan.

• The project will save approximately 2,700,000 barrels of oil annually or about 7,400 barrels on a per day basis.

• The project would have a positive impact on the national, regional and statewide economy.

III. The President's Energy Program.

A. Conservation

1. Transportation -- no apparent relationship.

2. Buildings -- no apparent relationship.

3. Appliances -- no apparent relationship.

4. Industrial Conservation -- no apparent relationship.

5. Cogeneration of Electricity and Process Steam.

• The project has relatively high efficiency and does not waste enormous amounts of energy in the generation of electric power.

6. District Heating -- no apparent relationship.

7. Utility Rate Reform -- no apparent relationship.

8. Taxes on Oil and Natural Gas -- no apparent relationship.

B. Management Information Systems.

1. Petroleum Production and Reserves Information -- no apparent relationship.

2. Petroleum Company Financial Data System -- no apparent relationship.

3. Emergency Management Information System -- no apparent relationship.

C. Industry Competition -- no apparent relationship.

D. State and Local Government Participation.

The Passamaquoddy Indian Tribal Council, Pleasant Point Reservation, Perry, Maine has proposed a small 2 - 5 Megawatt tidal power and mariculture development project in Half Moon Cove in Cobscook Bay, Maine. Both the International and/or All-American tidal power plans which this Division is re-evaluating would involve Cobscook Bay. The federal concepts offer various degrees of compatibility with the tribal plan and some construction modifications and mode of operations would be required to the tribal project if the large federal project is ever built. It has been recommended to the council that they coordinate their planning with the New England Division in respect to water pool levels, elevations and inverts of structures, etc., of their proposed facility. Their mariculture development would have to be coordinated with both their own and the federal tidal power projects in establishing pool elevations, retention and release of waters, etc.

Currently, the tribal council has prepared an unsolicited proposal dated March 1977 and is seeking approximately $400,000 fur further project planning purposes

E. Assistance for Low Income Persons --no apparent application.

F. Oil and Natural Gas -- Except for minimum requirements for maintenance activities the project will not use oil or natural gas.

1. Oil Pricing (legislative) -- no apparent application.
2. Oil Taxes (legislative) -- no apparent application.
3. Natural Gas Pricing (legislative) -- no apparent application.
4. Other Oil and Gas -- no apparent application.

G. Coal, Nuclear and Hydroelectric Power -- The tidal power project relies on harnessing the high tidewaters of Passamaquoddy and Cobscook Bays in New Brunswick and Maine and does not require conventional energy sources such as coal, oil or natural gas.

1. Oil and Natural Gas Users Tax (legislative).

It is felt that with the additional taxes which could be imposed on private electric generating utilities for utilizing oil, that the BCR economics of the tidal power project would improve.

2. Coal Conversion Regulatory Policy (legislative).

The tidal power plant would not be involved with conversion to coal, oil or gas fuels.

3. Environmental Policy for Coal.

The tidal power plant will not use coal and therefore is not involved with meeting emission standards for coal. In addition, the project will not have a solid waste disposal problem such as coal ash.

4. Coal Research and Development (Budget) -- no apparent application.

5. Nuclear Power -- no apparent application.

6. Hydroelectric Power -- this section states the following and since the Quoddy project is not an existing dam the section seems to have no apparent direct application:

"6. Hydroelectric Power. The President has directed the Corps of Engineers to report within three months on the potential for additional hydropower installations at existing dams throughout the country -- especially at small sites. Any recommendation will be subject to a thorough environmental and budget review before final decisions are made (administrative)."

H. Nonconventional Sources of Energy.

The tidal power project utilizes the high tides in the Passamaquoddy Bay region which are a dependable, renewable and inexhaustible source of energy. A project such as this assists the nation in its hope for long term economic growth beyond the year 2000.

It is noted that in addition to the current Corps of Engineers work on the Passamaquoddy Tidal Power Project, the Solar Energy Division of Energy Research and Development Administration and the U. S. Congress Office of Technical Assistance are both accomplishing separate tidal power studies which are investigating and reporting the economic feasibility of tidal power in the Passamaquoddy region.

1. Solar Energy -- See preceding comment, otherwise there is no apparent application with this section.

2. Geothermal Energy -- no apparent application.

I. Research, Development and Demonstration of Decentralized Systems.

1. Reorganization (Administrative/budget) -- no apparent application.

2. Solar, Geothermal and Other Technologies (budget) -- no apparent application.

J. Transportation Study -- no apparent application, except that the tidal power project would not have to depend on transportation service for supplying fuels.

12. In December 1976 the State of Maine Office of Energy Resources completed a report titled "Maine Comprehensive Energy Plan, 1976 Edition". The document reviews the energy situation, consumption and needs for the state. With respect to tidal power, their preliminary recommendations which could be undertaken concerning resource development and diversification are as follows:

By State of Maine entities -

Further consideration of tidal development as an energy alternative for Maine should await release of the ERDA study of tidal power. If eventual (within 30 years) technical and economic feasibility can be demonstrated for tidal power by life cycle cost calculations (being undertaken in the Stone and Webster study at Maine's request), then the Passamaquoddy Tidal Power site should be retained intact as an option for future energy supply to Maine.

By Regional or Federal entities

ERDA should plan to sponsor a Worldwide Tidal Power Conference jointly with the Atlantic Provinces Tidal Power Review Board in the Spring of 1977 when the tidal studies of both countries are completed.

13. In reviewing the All-American Plans and the current impediments which the development of nuclear power in New England is encountering there may be a future desire and need for an All-American Plan which will produce the maximum amount of energy rather than a principally peaking facility. In this event, single pool Plan D with 20 - 12,500 KW generators (250 MW) would be preferable as it will produce the greater amount of energy. In comparison, however, two pool Plan #4 without auxiliary will render a better B/C Ratio, provide more flexible use for providing peaking and maximum energy, but will produce less electricity on an annual basis. If the tidal power project is authorized for further study the plant use and mode of operation must be determined early. This would be done in conjunction with all concerned so that the proper tidal power plant will be planned which will be most advantageous for the State of Maine and New England.

14. Based upon the information developed in the basic draft report of 30 November 1976 and this Supplemental Report of 29 April 1977 the following discussion and findings on the economic feasibility of the project are provided:

a. <u>In relation to conventional method of evaluation</u>:

If the project cannot be considered economically feasible via the life-cycle methodology and the project is only analyzed by the present conventional methods of evaluation, then it appears that further study on tidal power in the Passamaquoddy region is not warranted and should not be continued for the following reasons:

(1) The proposed 500 and 1000 Megawatt International Passamaquoddy Tidal Power Projects have been evaluated in accordance with conventional methods and the Benefit-Cost Ratio for both size projects is below unity. Since power is the single purpose of the project, the B-C Ratio for power alone is only 0.53 for the 500 MW installation and 0.49 for the 1000 MW installation. If anticipated ancillary benefits from area redevelopment, fisheries and recreation are included, the B-C Ratio increases to 0.74 and 0.67 for the 500 and 1000 MW facilities respectively which is still less than unity.

(2) A conventional economic evaluation has also been made of five various one and two pool concepts which would be entirely within the boundaries of the United States. These have been referred to as "All-American" plans. The analysis for each of these concepts considering power benefits alone results in B-C Ratio in the 0.31 to 0.45

range, and when the other ancillary benefits from area redevelopment, fisheries-mariculture and recreation are included in the B-C Ratio increases to a range of 0.55 to 0.77 which remains less than unity.

(3) The results of the independent tidal power study by the U.S. Energy and Research Development Administration indicates that a tidal power project in the Passamaquoddy area is not economically feasible under present conditions when evaluated by the conventional means.

b. In relation to life-cycle evaluation of the project:

(1) In view of the changing times, present and apparent future dependency of the New England area on imported foreign fuel and its associated high costs, saving of natural resources (estimated annual savings of 2,700,000 BBLS of oil for the 500 MW project), escalation and views of other agencies, the life-cycle costing appears to have merit and deserves consideration for evaluating and determining the future of this energy oriented water resource project. It is suggested that higher authority review and make the decision on the possibility of evaluating the tidal power projects on a life-cycle costing basis, as under this method the separate life-cycle studies by the Energy Research and Development Administration, Office of Technical Assessment of the U.S. Congress, and the joint Federal Power Commission, New England Division indicate that the project would be economically feasible over the 50/100 year life span of the project. It is recognized that this is not the authorized or conventional method of evaluating water resource projects, however, it deserves consideration before a final decision is made to cease further study on the tidal power project.

(2) If a decision is rendered to proceed with further study recognizing the life-cycle analysis as a basis for the economics of the Survey Scope Study Report, it is considered that an All-American Tidal Power Project should be studied in the event that Canadian officials do not concur with participation in an international plan. The specific All-American plan is to be determined during the Survey Scope Study period.

c. <u>That the energy amenities of the tidal power project such as</u>

(1) The availability and utilization of ocean tides which are a predictable and daily renewable energy resource.

(2) The conservation of natural resources.

(3) Repayment capability.

(4) Minimum polluting operation and waste disposal aspects and

(5) Minimum land takings.

be considered in evaluating the project even though it does not meet the "net benefits rule" in economic evaluation. These advantages make the project unique with possible overriding economic and energy considerations in light of the present regional and national energy problems.

15. If decision is made to proceed with the preparation of a Plan of Study, the next forseeable critical issue is to determine whether the International or All-American Tidal Power Project should be studied. This will first necessitate a meeting with the Canadians to obtain their formal views and position on a new joint Quoddy project and study. If Canada indicates formal disinterest in the International project then it appears that the United States would be without obligatory constraint

to study and plan an All-American Tidal Power Project. In such an event, it appears that our advising Canada of our intent to study an All-American Tidal Project would be an extension of international courtesy.

B. Recommendations

Based upon the results of the project Economic Feasibility Report dated 30 November 1976 and this Supplemental Report dated 29 April 1977, the Reporting Officer recommends that:

a. Under the present conventional Benefit-Cost Ratio (BCR) method of evaluation as dictated by Congress for water resource projects, further study of the All-American and/or International Passamaquoddy Tidal Power Projects is not warranted and should be discontinued.

b. However, in the view of the current energy situation, higher authority and the Congress of the United States consider authorizing the "life-cycle" method of analysis as the economic basis for the Tidal Power Project and justification for further study of tidal power in the Passamaquoddy region.

c. If higher authority and the Congress of the United States authorizes the use of life-cycle analysis as the basis for the project, it is recommended that this Division be authorized to prepare a Plan of Study for an International or All-American Tidal Power Plan pending Canadian interest, and upon its approval, continue with further study and determine the optimal tidal power plan during the Survey Scope Study period.

d. That interested Federal, State and local agencies, private groups, Canadian authorities and the International Joint Commission be advised of the results of this Economic Feasibility Study and comments from higher authority as soon as possible for their information and future planning purposes.

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

ATTACHMENTS

Attachment No. 1

NEW ENGLAND SYSTEM CAPABILITY*

Type of Installation	Mode of Operation	Actual Dec. 75 MW	Capability 1975/76 thru 1986/87: NEPOOL Authorized Additions MW	NEPOOL Planned Capability** MW	Proposed Additions Under Study or Planned MW	Proposed Gross Capability MW
Nuclear	B	3364	8910	12371	1150	13521
Conventional Thermal	B/M	11914	1160(M)	13062	--	13062
Net Power Purchases	B/M/P	192	21	213	--	213
Combined Cycle	M	90	385	475	180	655
Hydro	B/M/P	1288	--	1273	12	1285
Gas Turbine	P	1489	120	1609	105	1714
Diesel	P	243	--	243	44	287
Pumped Hydro	P	1632	--	1632	--	1632
Fuel Cells	P	--	--	--	26	26
Peaking Fossil	P	--	--	--	150	150
TOTAL		20212	10596	30878	1667	32545
Estimated peaking capacity (20%)		4000		6000		

* New England Load and Capacity Report, 1975-1986. NEPLAN, January 1, 1976.
** Including authorized reratings and retirements.

B = Base-Load Plant
M = Mid-Range Plant
P = Peaking Plant

Attachment No. 2

SUMMARY

SYSTEM CAPABILITIES AND ESTIMATED PEAK LOAD - WINTER - 1977/78-1987/88

MW

	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
otal Capability* Item #25	21950	22568	22569	22572	23984	25255	26407	28732	28531	30631	30630
otal Peak Load Item #26	15217	16051	16918	17846	18820	19814	20851	21964	23134	24379	25694
Reserve Before Maintenance Item #27	6733	6517	5651	4726	5164	5441	5556	6768	5397	6252	4936
% Reserve Before Maintenance Item #28	44.2	40.6	33.4	26.5	27.4	27.5	26.6	30.8	23.3	25.6	19.2
Scheduled Maintenance Item #29	400	900	800	0	0	0	0	0	0	0	0
Reserve After Maintenance Item #30	6333	5617	4851	4726	5164	5441	5556	6768	5397	6252	4936
% Reserve After Maintenance Item #31	41.6	35.0	28.7	26.5	27.4	27.5	26.6	30.8	23.3	25.6	19.2

* Additions include only "NEPOOL Planned" generating capacity.

Includes 278.25 MW of deactivated reserve through October, 1983, and 196.75 through remainder of report.

Data from NEPLAN, January 1, 1977

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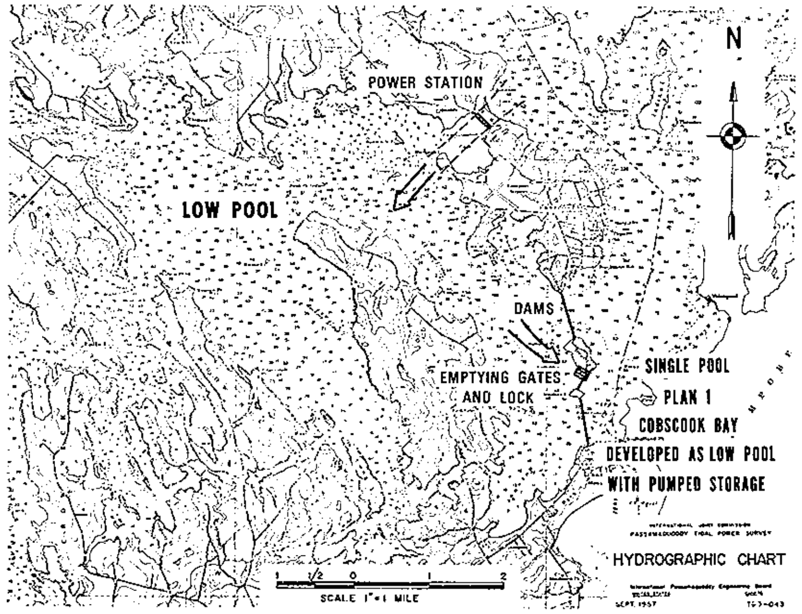
GENERATION ADDITIONS, RERATINGS AND RETIREMENTS (MW)

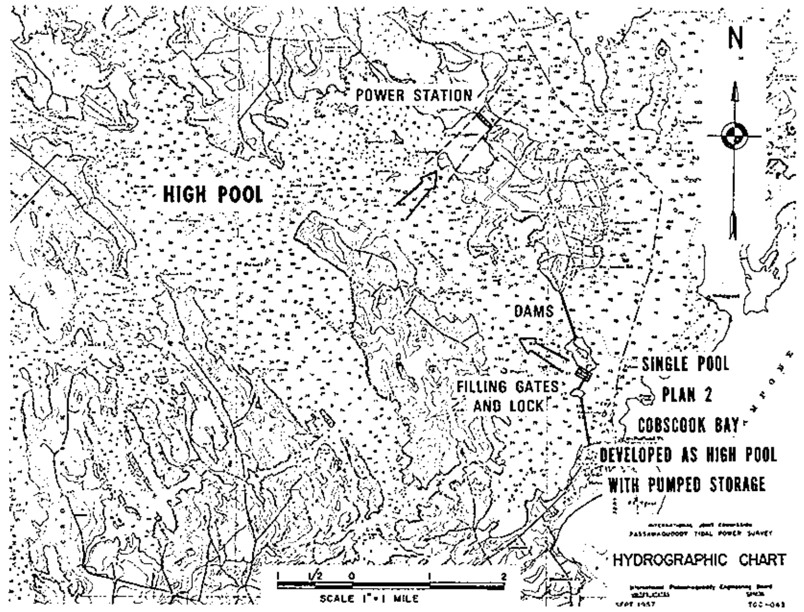
Attachment No 3

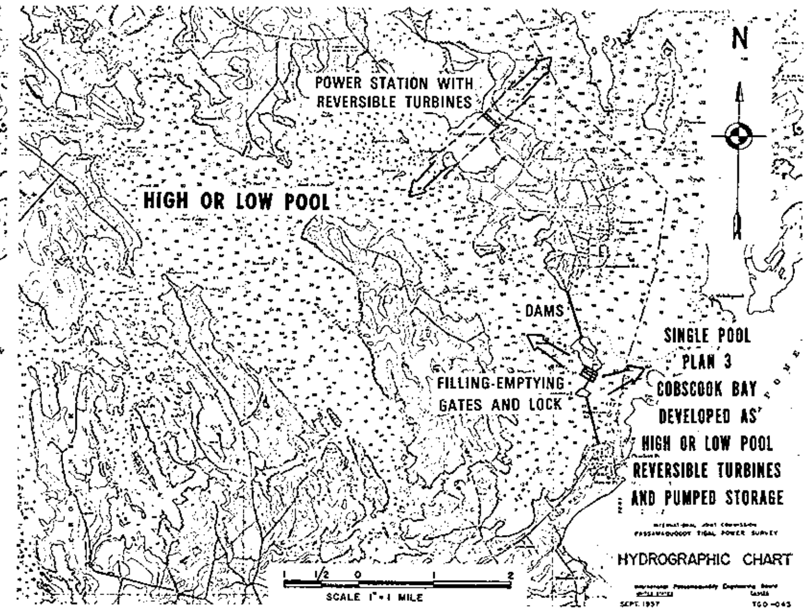
	Winter 1977/78	Winter 1978/79	Winter 1979/80	Winter 1980/81	Winter 1981/82	Winter 1982/83	Winter 1983/84	Winter 1984/85	Winter 1985/86	Winter 1986/87	Winte 1987/
Existing Capability	21457	21576	21594	21595	21598	21590	21591	21674	21669	21468	2126
Retirements	-6	0	-2	0	-9	0	0	-6	0	0	
Reratings	+112	+16	0	0	0	0	+81	0	0	0	
Adj. for Purchases & Sales	+13	+2	+3	+3	+1	+1	+2	+1	-1	0	-
MEPCO/NB Purchase	-	-	-	-	-	-	-	-	-200	-200	
Net Capability	21576	21594	21595	21598	21590	21591	21674	21669	21468	21268	2126
Deactivated Reserve Units	278	278	278	278	278	278	278	197	197	197	19
Adj. for Deactivated Reserve Units	-	-	-	-	-	-	-81	0	0	0	
NEPOOL Planned Units											
Potter #2 (1/1/77)	96	96	96	96	96	96	96	96	96	96	9
W. F. Wyman #4	-	600	600	600	600	600	600	600	600	600	60
Mass. Municipals - CC	-	-	-	-	270	270	270	270	270	270	27
Seabrook #1	-	-	-	-	1150	1150	1150	1150	1150	1150	115
Millstone #3	-	-	-	-	-	1150	1150	1150	1150	1150	115
Mass. Municipals - CT	-	-	-	-	-	120	120	120	120	120	12
Seabrook #2	-	-	-	-	-	-	1150	1150	1150	1150	115
Pilgrim #2	-	-	-	-	-	-	-	1180	1180	1180	118
NEPCO #1	-	-	-	-	-	-	-	1150	1150	1150	115
Sears Island	-	-	-	-	-	-	-	-	-	1150	115
NEPCO #2	-	-	-	-	-	-	-	-	-	1150	115
Total Capability *	21950	22568	22569	22572	23984	25255	26407	28732	28531	30631	3063

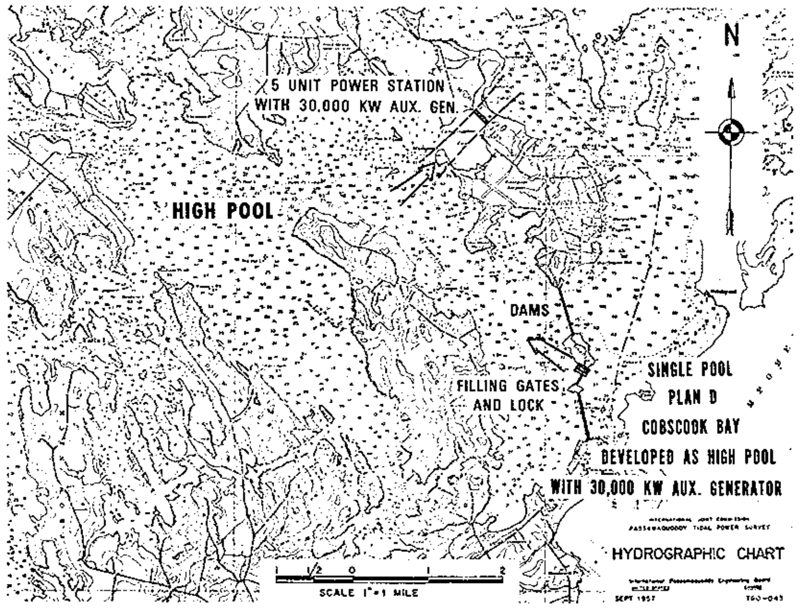
*NOTE: Additions include only "NEPOOL Planned" generating capacity. Data from NEPLAN January 1, 1977.

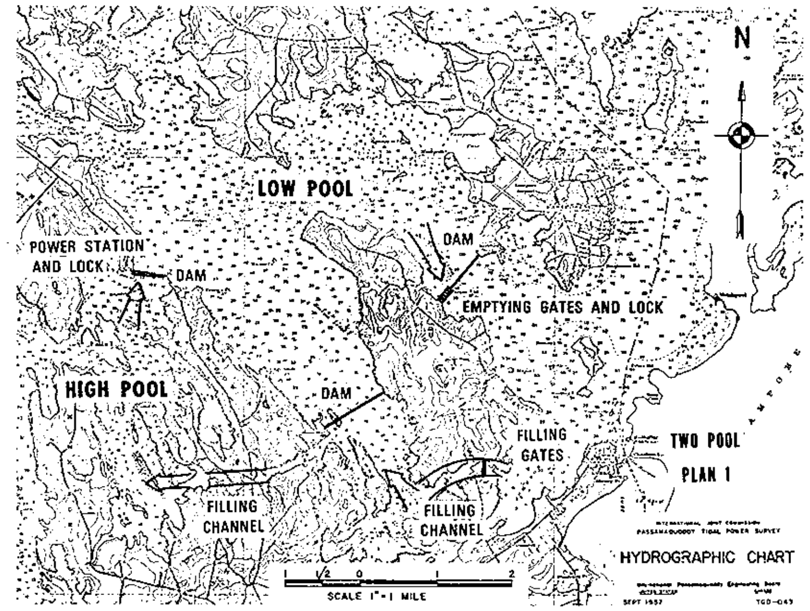
Deactivated Reserve Units as of 1/1/77 = 140.3 of NU capability, 81.5 MW of EUA capability, and 56.45 MW of UI capability.

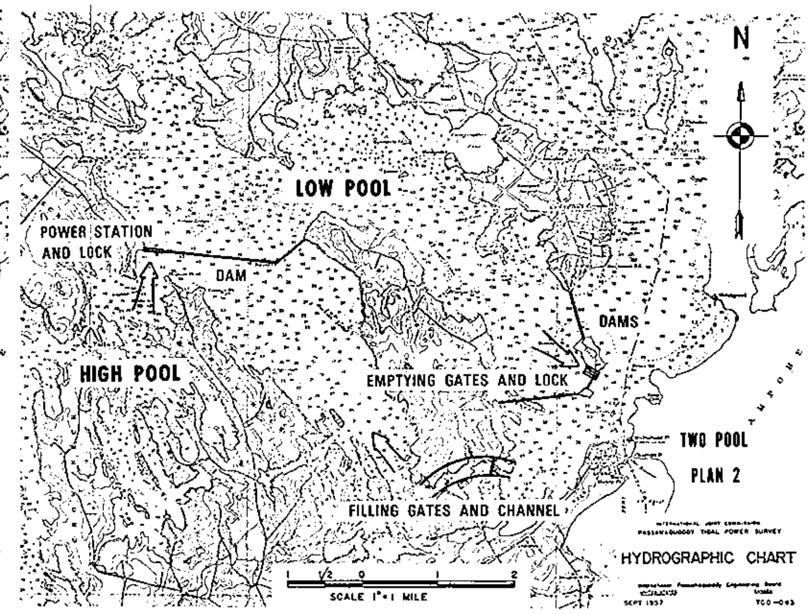


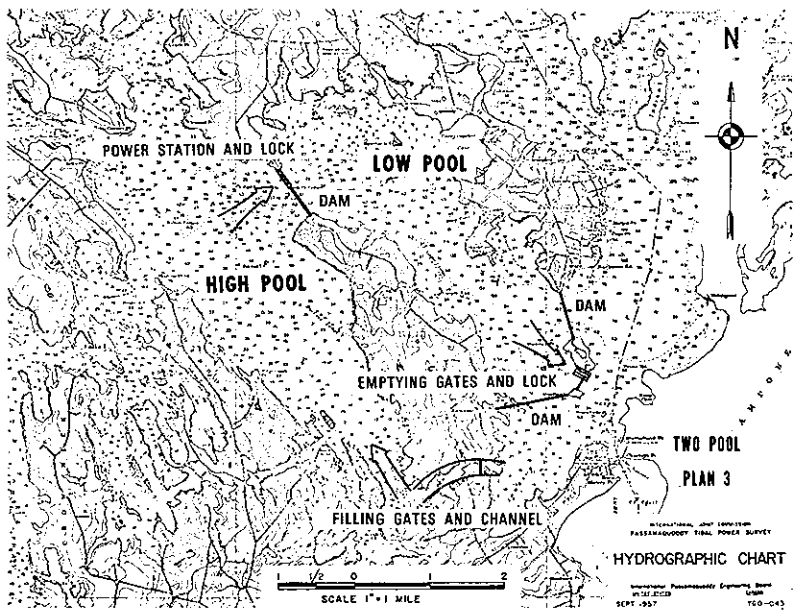


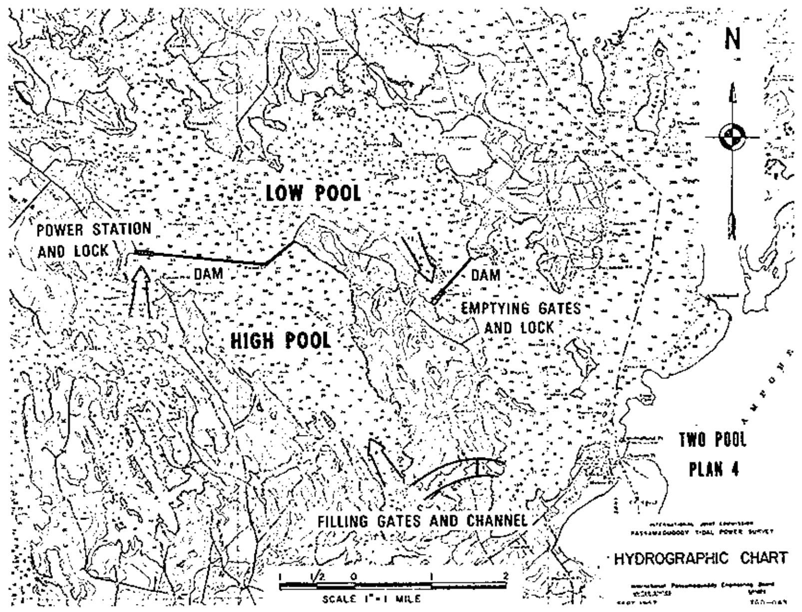












ATTACHMENT 4

TIDAL POWER IN COBSCOOK BAY ALL AMERICAN 1935 PLANS

NEW ENGLAND DIV.

SUPPLEMENTAL REFERENCES

1. Institute for Water Resources Research Report 75-R1, dated 11 July 1975, titled "Hydroelectric Power Potential at Corps of Engineers Projects."

2. Draft of Final Report titled "Tidal Power Study" dated January 1977 prepared by Stone & Webster Engineering Corporation for the U.S. Energy Research and Development Administration, Division of Solar Energy, under Contract No. E(49-18)-2293.

3. Memorandum dated 19 February 1936 by United States Engineer Office, Eastport, Maine, subject: Comparison of Best American Two Pool Tidal Hydro-electric Plan with Single Pool.

4. Memorandum dated 22 May 1936 by United States Engineer Office, Eastport, Maine, subject: Revised Estimate of Plan "D".

STATE OF MAINE
OFFICE OF THE GOVERNOR
AUGUSTA, MAINE
04330

JAMES B. LONGLEY
GOVERNOR

September 7, 1976

John Leslie
U. S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

I realize the Federal government is studying tidal power to determine its feasibility, especially in Passamaquoddy Bay.

We are of the opinion that, in order for these studies to be worth the taxpayer dollars being spent on them that they must include a per KWH life cycle cost analysis of the proposed Quoddy project and a comparison of the projected cost of the alternatives (nuclear, coal, oil-fired and river hydro) ten or twenty years from now, when the next large scale generating facilities will actually be needed.

We are greatly disturbed that neither the Corps of Engineers nor ERDA has seen fit to include this type of cost projection in the scope of work to be performed by the Stone and Webster Company, although Mr. Wayne has publicly recognized that if Quoddy had been built years ago its power would be a bargain today.

We feel no one is going to be enlightened by a study which quantifies the obvious, namely that Quoddy will cost more to build now than 20 years ago, or that it will cost more to build than some other type of facility. What we need to know from a power-cost standpoint is the value of Quoddy in ten or twenty years with the fuel costs of other types of power rising? We also would like to know from an overall public investment standpoint, what would be the external benefits of the project to the affected region, which is characterized by its remoteness, coldness, low-incomes and high energy costs?

Until your studies attempt to answer these questions in a preliminary fashion, we must conclude that they are not only worthless as a planning tool, but may actually produce

ATTACHMENT NO. 6

prejudices which would forever condemn the Quoddy project as "economically unfeasible" and thus deprive the State and the Nation of our best hope for a tidal project.

We feel that it is feasible for you to make the projections we have described within the terms and budgets of your current contracts, and look forward to a letter from you stating that you have indeed decided to do so.

Very truly yours,

James B. Longley

JAMES B. LONGLEY
Governor

JBL/gwd

cc: Abbie Page, Director, Office of Energy Resources
Allen Pease, Director, State Planning Office

NEDED

24 September 1976

Honorable James B. Longley
Governor of the State of Maine
State House
Augusta, Maine 04330

Dear Governor Longley:

This is in response to your letter of 7 September 1976 addressed to Mr. John Wm. Leslie of my staff relative to the economic analysis of the Passamaquoddy Tidal Project now under study.

Your proposal of a life cycle cost analysis, as you may know, is not the conventionally dictated method of analysis as established by the Congress for the evaluation of water resource projects. However it can be developed and based upon approval of our Washington headquarters, we will develop same for your personal use.

As you have probably been informed, Mr. Leslie met with Mrs. Page and Mr. Silverman on 15 September 1976, at which time the subject matter was discussed. I would like to again reiterate some of the key points and warnings in respect to use of projected power benefits that would be required in an economic analysis. There is no problem in establishing the estimate of the project in today's market which is readily converted to an annual cost thus providing the cost side of the benefit to cost equation. The creditability of the benefit side will depend on a great number of assumptions: what will be the least expensive privately-financed alternative; what will be the price of alternative fuel; how will energy forms of generation change, if any; what will be the value of power; what will be the state of the national economy. All of these

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must be projected to the year 1991, the projected date of power on line. Thus benefits will have to be qualified with a statement of the assumption.

As to your comments on external benefits, these are normal factors of any report and of course will be so addressed.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer